Control ENGINEERING

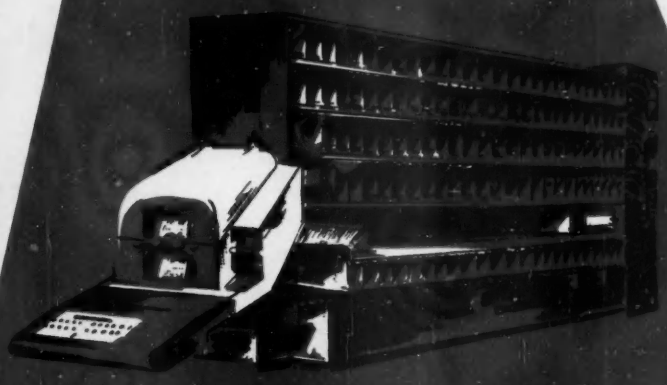
INSTRUMENTATION AND AUTOMATIC CONTROL SYSTEMS

A McGRAW-HILL PUBLICATION
60 CENTS
NOVEMBER 1957

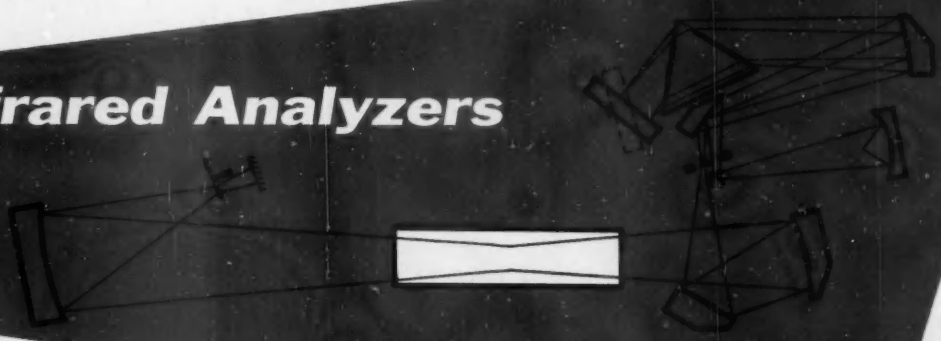


Calculating Gyro Torque

Sorting Mail Automatically



Infrared Analyzers



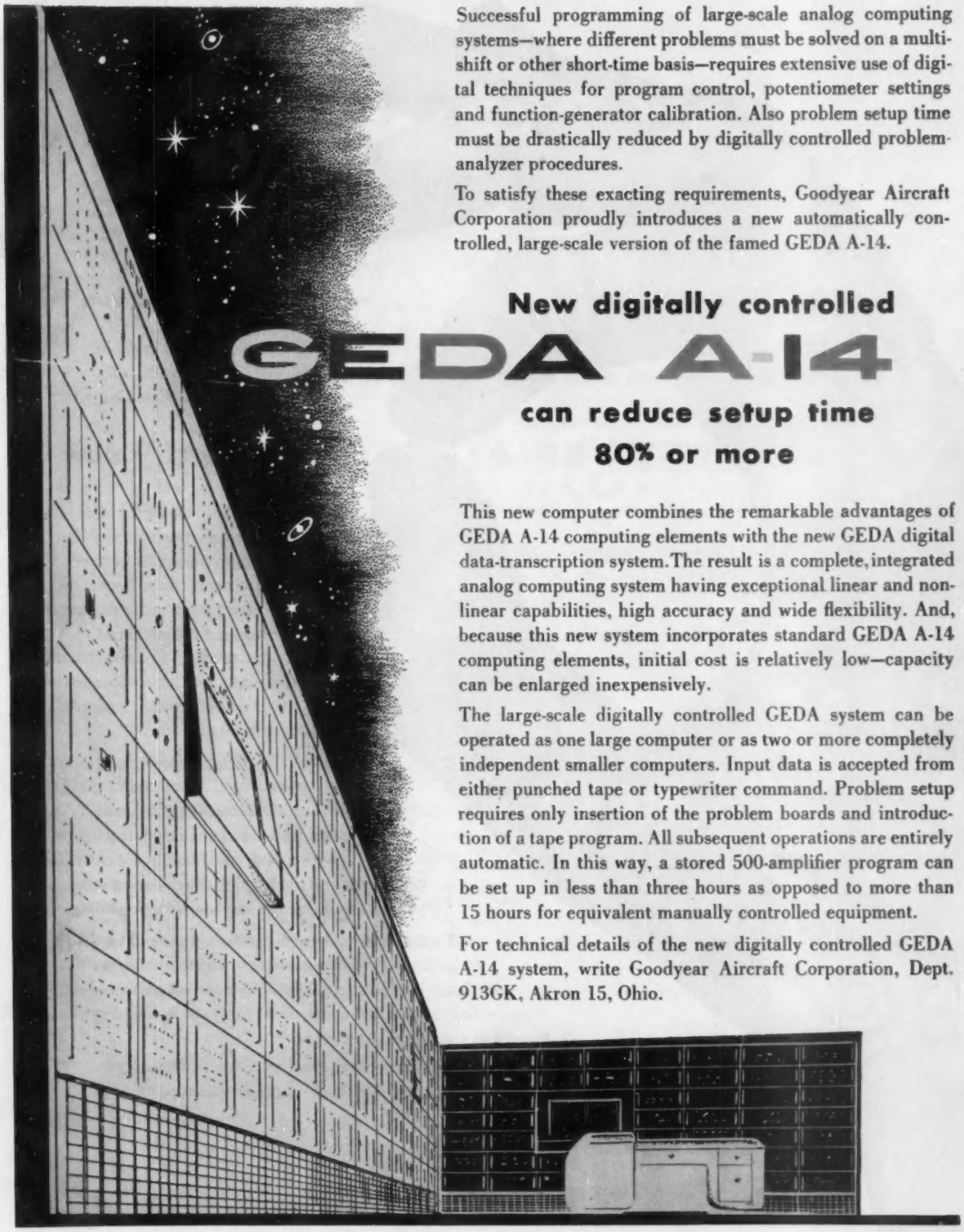


The demands of computer and control projects and problems over a 20-year period have earned for Librascope an enviable record of experience which is demonstrated by versatility and reliability in the design, development and manufacture of successful equipment. New demands of missile projects are reflected in Librascope's *profiles of experience*. This knowledge can be focused on *your* computer-control problems with the assurance of success. Librascope invites your inqury in this field. A letterhead request will bring you the Librascope story.

Engineers interested in challenging new fields are invited to contact Glen Seltzer, Employment Manager.

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Successful programming of large-scale analog computing systems—where different problems must be solved on a multi-shift or other short-time basis—requires extensive use of digital techniques for program control, potentiometer settings and function-generator calibration. Also problem setup time must be drastically reduced by digitally controlled problem-analyzer procedures.

To satisfy these exacting requirements, Goodyear Aircraft Corporation proudly introduces a new automatically controlled, large-scale version of the famed GEDA A-14.

New digitally controlled

GEDA A-14

can reduce setup time 80% or more

This new computer combines the remarkable advantages of GEDA A-14 computing elements with the new GEDA digital data-transcription system. The result is a complete, integrated analog computing system having exceptional linear and non-linear capabilities, high accuracy and wide flexibility. And, because this new system incorporates standard GEDA A-14 computing elements, initial cost is relatively low—capacity can be enlarged inexpensively.

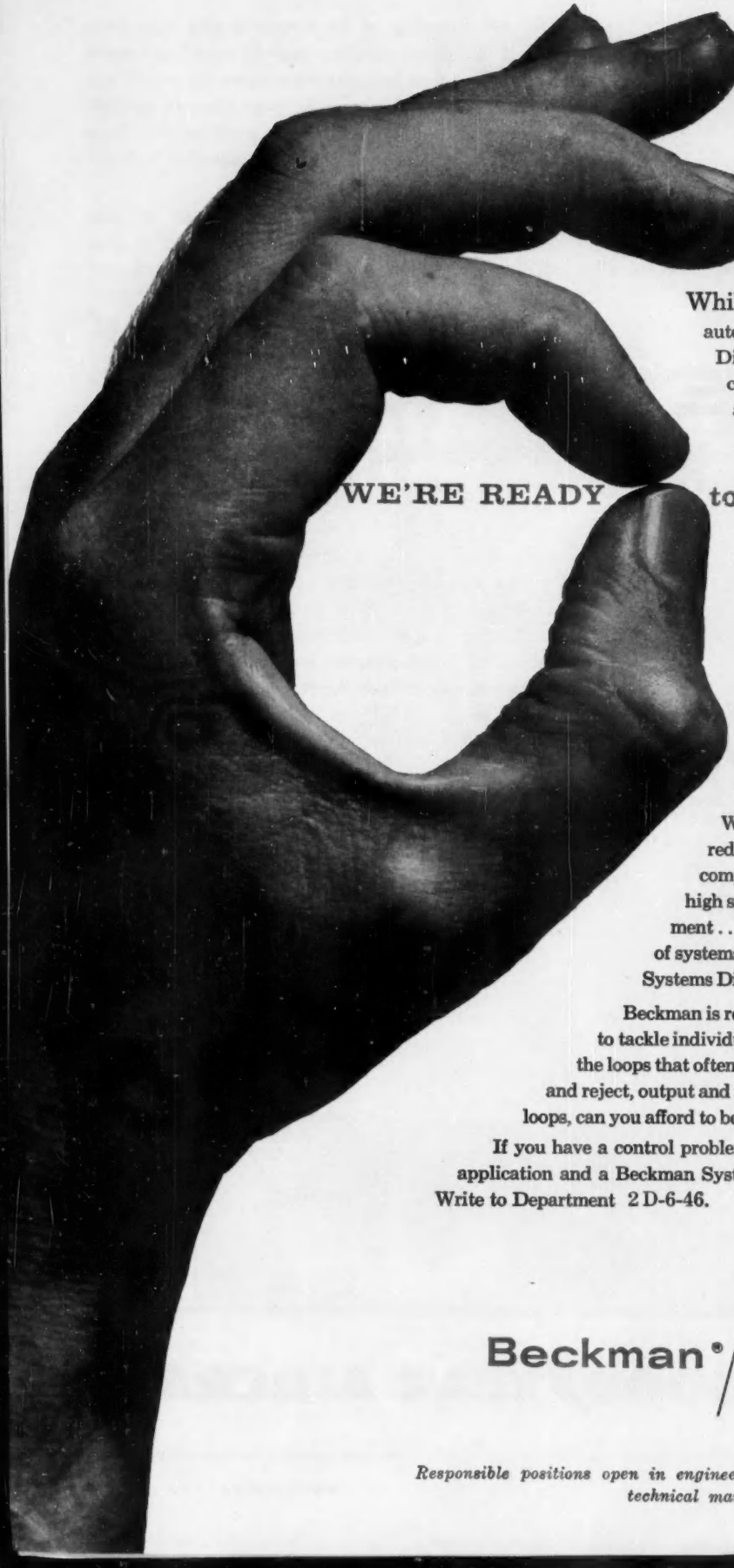
The large-scale digitally controlled GEDA system can be operated as one large computer or as two or more completely independent smaller computers. Input data is accepted from either punched tape or typewriter command. Problem setup requires only insertion of the problem boards and introduction of a tape program. All subsequent operations are entirely automatic. In this way, a stored 500-amplifier program can be set up in less than three hours as opposed to more than 15 hours for equivalent manually controlled equipment.

For technical details of the new digitally controlled GEDA A-14 system, write Goodyear Aircraft Corporation, Dept. 913GK, Akron 15, Ohio.

GEDA ANALOG COMPUTERS

GOODYEAR AIRCRAFT

GEDA—T. M. Goodyear Aircraft Corporation, Akron 15, Ohio



While many people *talk* automatic control, Beckman Systems Division is "closing loops" the country over . . . in steel mills, in aircraft and textile plants, in the petrochemical industries. Not yet

WE'RE READY to close the loop **now**

fully automatic *manless* plants – but *manless* installations, production lines, and processes. From wind tunnels to paper mills, Beckman has provided the systems engineering experience and the advanced hardware necessary to convert manual and semi-automatic operations to the fully automatic efficiency required in the new industrial era.

With reliable data processing and data reduction systems . . . with digital timing, computing, and recording equipment . . . with high speed digital and analog control equipment . . . with a firm, sure hand in the entire field of systems and applications engineering – Beckman Systems Division can close loops for you *now*.

Beckman is ready with the know-how and hardware to tackle individual processes or entire plants, to close the loops that often spell the difference between product and reject, output and upset, profit and loss. In a time of closing loops, can you afford to be left out?

If you have a control problem, send us a description of the application and a Beckman Systems Engineer will contact you. Write to Department 2 D-6-46.

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325 N. Muller Ave., Anaheim, California
a division of Beckman Instruments, Inc.

Responsible positions open in engineering, manufacturing, technical marketing. Write for Career File 10.

Control ENGINEERING

NOVEMBER 1957
VOL. 4 NO. 11

Published for engineers and technical management men who are responsible for the design, application and test of instrumentation and automatic control systems

97 **At White Sands They Track Missiles in the Lab and on the Range**
L. H. YOUNG of CONTROL ENGINEERING reports on the simulation techniques and flight test instrumentation at the U. S.'s first – and still busiest – missile proving ground.

104 **Use Capacitance for Accurate Level Measurement**
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108 **Sensing Nulls with Dual-Range Compression Circuits**
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111 **How to Avoid Extra Integrators when Simulating RLC Networks**
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115 **Data File 10 – Calculate Gyroscope Precession Torques**
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Special feature this month: comprehensive review of Russian book on magnetic amplifiers.

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Michel Mamon – specialist in applying magnetic amplifiers to instrumentation and automatic control – was educated at the University of Paris and is now a U. S. citizen. A CtE author, he mentioned to us some time ago the importance of translating Soviet technical literature to find out not only what the Russians have accomplished, but also what they have not. For instance, Michel notes that a search of recent Russian publications (see p. 205) revealed no mention of silicon rectifiers, perhaps because they are unknown or unavailable in the U. S. S. R. Conclusion: the Russians may be handicapped in high-temperature applications of magnetic amplifiers.

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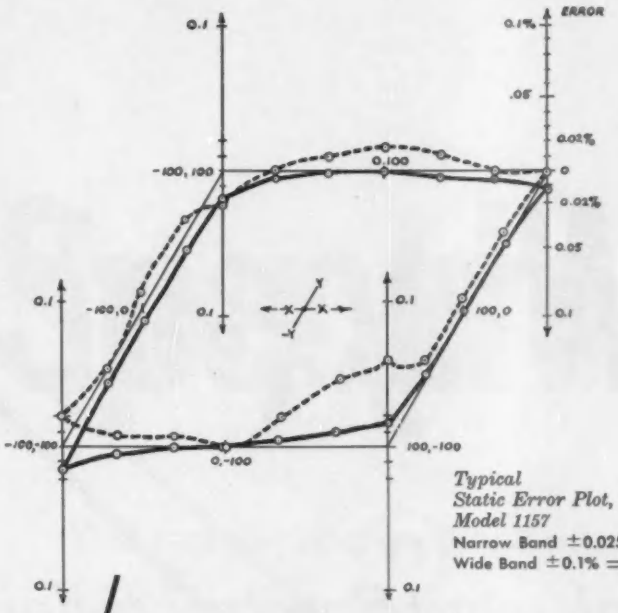
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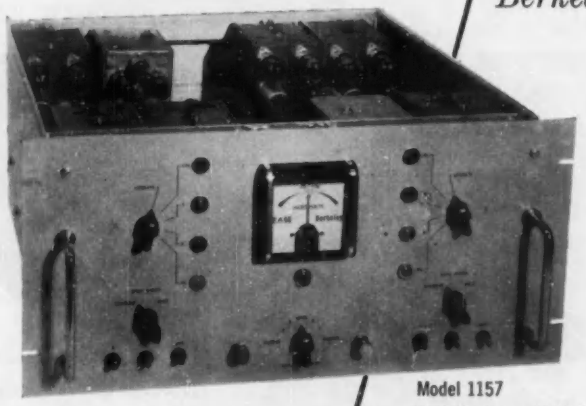
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Linear Accuracy



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Static Error Plot,
Model 1157
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Wide Band ±0.1% = – – – –

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ELECTRONIC MULTIPLIER



Model 1157
Dual Electronic Multiplier

Beckman/Berkeley's Model 1157 electronic multiplier provides for the first time a unit offering both high accuracy and wide frequency response. It is the most accurate tool available for multiplying two varying voltages in the range of +100 to −100 volts. In addition, the carrier frequency of Model 1157 may be increased, providing greater band width for the output variable.

Another important feature of the new EASE* multiplier is its versatility. By energizing a relay within Model 1157, the unit becomes a divider without the use of any external components. Furthermore, its internal amplifiers may be used as operational amplifiers at the user's discretion, increasing the capacity of existing equipment. These internal amplifiers are chopper stabilized for low drift. Rugged construction, the extensive use of premium components and plug-in modules, including amplifiers and switching circuitry, simplify maintenance and improve reliability.

SPECIFICATIONS

STATIC ACCURACY
NARROW BAND RANGE: Product accurate to better than 0.01% of full scale in any one quadrant (full scale = 200 volts). Product accurate to better than 0.025% of full scale in all four quadrants.
WIDE BAND RANGE: Product accurate to better than 0.05% of full scale in any one quadrant. Product accurate to better than 0.1% of full scale in all four quadrants.

DRIFT
NARROW BAND RANGE: Less than 20MV (0.01% of full scale) over any 6-8 hour period.
WIDE BAND RANGE: Less than 60MV (0.03% of full scale) over any 6-8 hour period.

DIVIDER OPERATION
Provides circuitry for converting each multiplier channel to a divider by energizing a relay from patchboard. Output = 100X/Y; Y negative.

AMPLIFIER USE AS INVERTERS
Patchboard energizing of a relay allows the three Model 1048B Amplifiers per channel to be used as inverters when unit is not being used as a multiplier.

Complete technical specifications on the Model 1157 Dual Electronic Multiplier are available on request. Please address Dept. L11.

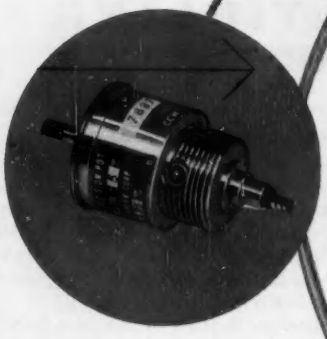
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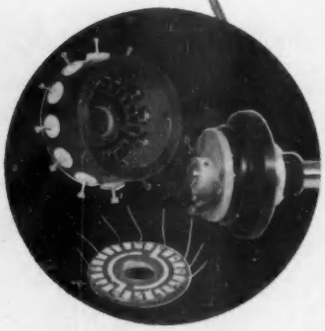
Why pot specs

Look what Spectrol is doing for designers



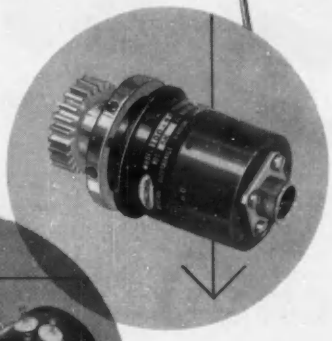
Custom-designed to measure rate of flow in jet aircraft fuel system

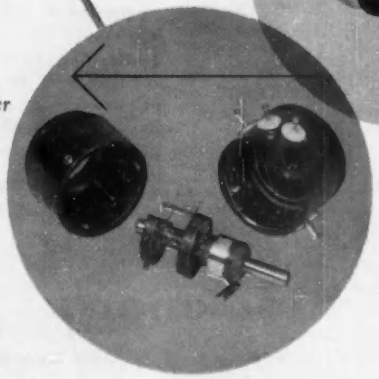
Specially designed to be immersed in fuel, both the stainless steel housing and shaft gear are gear-driven independently—electrical connection is made through the external slip ring assembly mounted in line with the shaft.



Unique miniature corrosion-free switch pot

Specifically designed for a precise multiple switch application . . . this miniature unit combines a printed circuit wafer with Rhodium plated segments for long, corrosion-free life in a rugged anodized aluminum package.





Center-positioning pot for a barometric altitude computer

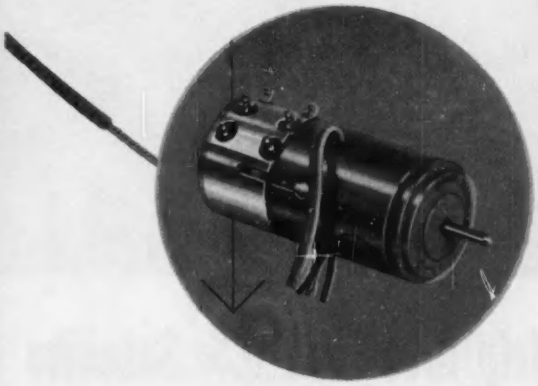
This pot was designed to give a torque of only 0.75 oz./in. and a position return accuracy of 0.5% of the applied voltage. Mechanical rotation is limited by internal stops which withstand a 3.0 in./lb. static load.

Special design for an airborne FM-FM telemetering missile system

One of these transducers modulates each of the 12 channels in the system. The plug-in connector replaces standard terminals to facilitate quick changes.

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in record time!



Space problem solved by Spectrol's precise "in-line" mechanism

A double element potentiometer assembled directly on the "Autosyn" shaft without gear train or coupling devices to give maximum economy of space and weight.

You can depend on Spectrol to design and deliver the pot you need when you need it

Send us your requirements or write for Spectrol's catalog describing the complete line and the name of our representative in your area. For precision prototypes *in record time*, you can depend on Spectrol's highly experienced engineering staff. Our reliability program assures unsurpassed performance.

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- ☐ Linearity Testers
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Philco Surface Barrier Transistors Help Give First U.S. Satellite

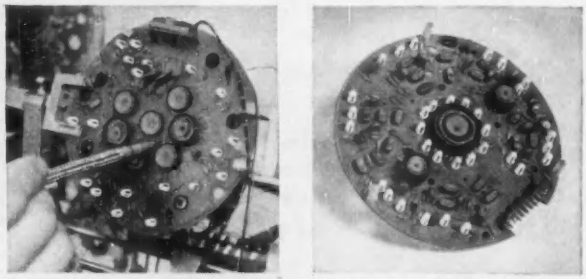
As the first U.S. Satellite flashes through Outer Space in its orbit around the Earth, tiny Philco Surface Barrier Transistors will be helping to operate the complex scientific instruments it carries.

Project Vanguard, a major activity of the International Geophysical Year, is being undertaken for the purpose of gathering original data, vital to International Science as the first giant step in man's eventual conquest of the Universe.

While the Earth Satellite is orbiting in its trackless path, data on temperatures, radiations, micro-meteors and other phenomena will be collected and transmitted back to Earth.

Because of their proven reliability, low current requirements, extremely light weight and miniature size, Philco Surface Barrier Transistors have helped solve the gigantic problems of reliability and miniaturization in electronic operation of these Satellite instruments.

Philco Surface Barrier transistors are literally *in the Vanguard* of modern electronics . . . helping make possible the success of Project Vanguard!



Telemetering pre-modulator circuit cards being assembled at U.S. Naval Research Laboratory, Washington, D.C.



a "Voice"... at 18,000 MPH... From Its Orbit In Space!

Philco SBT's Still Operate After 126-Mile Plunge To Earth In Early Satellite Flight Test!

Circuit cards carrying Philco SBT's were recently sent aloft in a flight test at White Sands. The rocket attained an altitude of 126 miles . . . fell back to Earth (landing on a granite boulder). Although the housing was badly smashed . . . all Philco SBT's (except one . . . which was lost at point of sphere puncture) continued to operate with original performance characteristics!



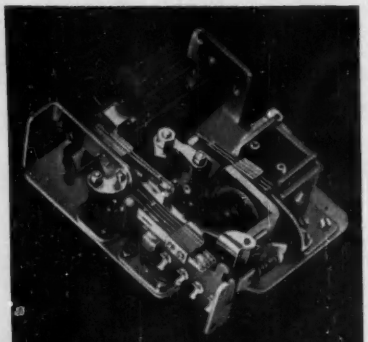
Smashed metal housing in which Philco Surface Barrier Transistors fell 126 miles during early Satellite vehicle flight test.



Close-up of actual circuit card, with plastic covering cut-away to show Philco SBT's . . . still intact and operable!

Write, wire or telephone for complete information on all Philco transistors.

PHILCO LANSDALE TUBE COMPANY DIVISION
LANSDALE, PENNSYLVANIA



Rugged XY® Deca Switch

for your selecting and control operations

This direct-drive impulse-controlled stepping switch (reset type) is designed to perform control and selecting functions in industrial and communication applications.

The lightweight Deca Switch offers exceptional reliability and compact ruggedness, plus these added features:

- positive stepping action with special locking device to eliminate bounce of wipers and off-normal contacts when the switch returns to the home position;
- 4 banks of 11 contacts each;
- such time-proven XY advantages as dust-free vertical wire banks, bifurcated wipers, dependable release magnet mechanism, and long-wearing, case-hardened working parts with Parco-Lubrite rust-resistant, oil-retaining finish;
- fast operate and release time.

You can order XY Deca Switches in a wide variety of off normal and release magnet spring combinations to suit your specific requirements. Compact and light, the switches are 4¾" long, 4" wide, 1½" high and weigh 20¼ ounces.

Complete technical details are contained in Bulletin T-5001, available on request.

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SHOPTALK

CtE Breaks into Print

Shortly after the September 1956 issue of CtE appeared (theme: "How to Practice Control Systems Engineering"), the McGraw-Hill Book Co. asked permission to publish the feature articles in this issue in book form. Always appreciative of more reader interest, and eager to spread the gospel further, CtE's editors immediately agreed. To make the book more useful, an equal amount of reference-type information from other issues was added to the September '56 material. As can be seen from the cut, the *Control Engineering Manual* is now available from the McGraw-Hill Book Co. to those who want their data on control systems engineering and many important phases of automatic control system design in permanent bound form.



It looks as though this will be only the first of many books that will come from CtE-published material. Two more are definitely beyond the conjecture stage, and the future looks bright for still others.

•

Specialists Needed

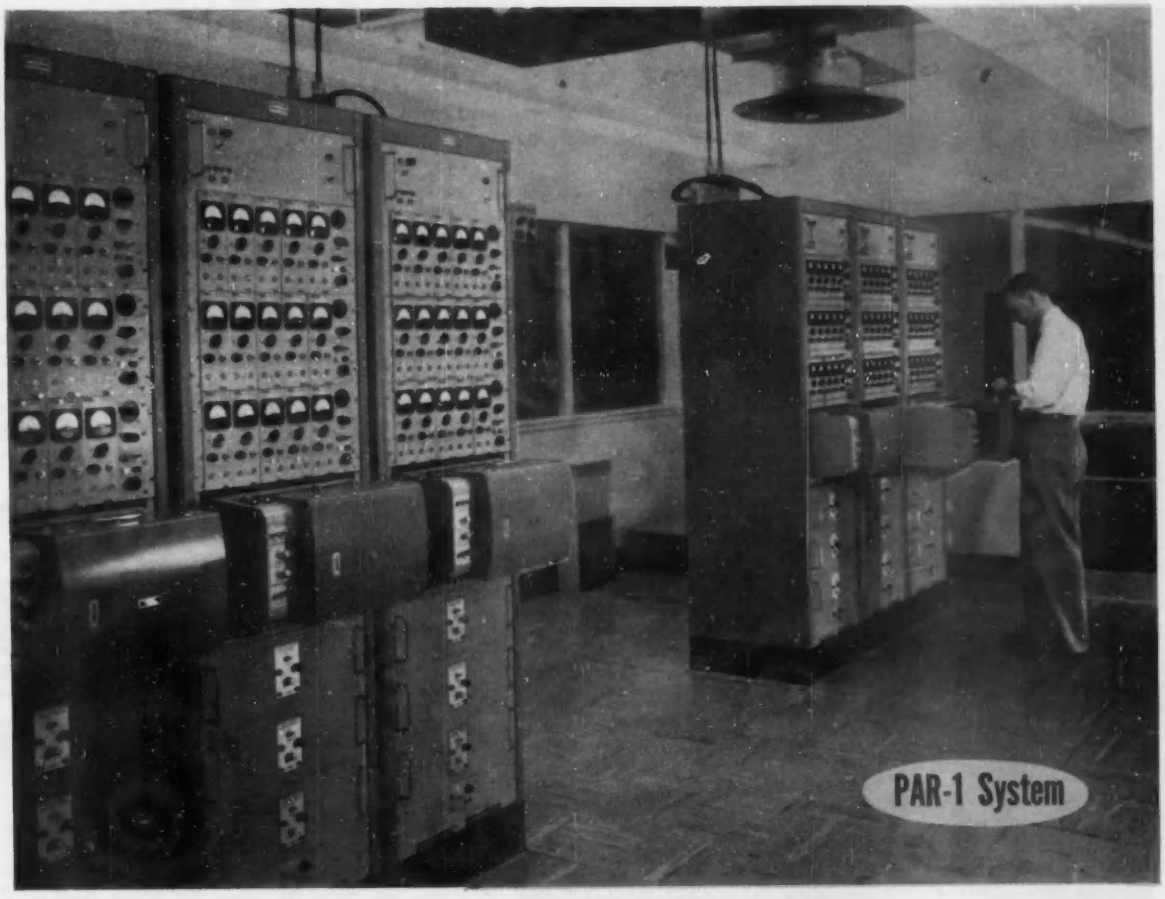
Thought you might be interested in a brief report sent to us by Kemp Anderson, McGraw-Hill Southwestern News Bureau Representative, on a visit he made to a "pushbutton-operated" pipeline station. Says Kemp: "The company arranged to shut down one of the stations to show us the operations that were involved. As you might guess, when they attempted to start the station nothing happened. It finally turned out that one of the button-pushers hadn't pushed the button right and the button had hung up. Guess that's a hazard of pushbutton-operated stations, lack of trained buttonpushers. With 'automation' pushing in on us it might not be a bad idea to have some of the colleges offer a course in *Pushbutton Pushing*."

•

Digital Application Reprint Ready

True to the promise made in the July *Shoptalk*, the complete Digital Application Series has been reprinted in one neat booklet and is now available at a single-copy cost of $3. Contact Mrs. Florence Baxley, Readers Service Dept., CONTROL ENGINEERING. Those readers who have already ordered copies will receive them shortly if they haven't already.

MI Precision Analog Recording System



GENERAL ELECTRIC INSTALLS MIDWESTERN INSTRUMENTS' PAR-1 SYSTEM

Philadelphia, Pa.: A news release from General Electric's Missile and Ordnance System Department announces the installation of Midwestern Instruments Precision Analog Recording System. This modern, efficient and automatic processing and computation center is a major facility in General Electric's advanced program of missile development and design.

This newest Precision Analog Recording System was designed and perfected by **MI** to provide an extremely accurate method of obtaining an oscillographic record of analog parameters obtained from objects under study. The exceptionally stable amplifiers are of modular construction and are directly interchangeable.

The PAR system also provides a precise method of operating on the input signals which can be scaled and positioned between grid lines on the oscillograph record to have a direct relation to the original physical stimulus thus permitting easier data reduction. This operation on the input signals can be accomplished manually or it may be programmed by punched tape.

Features:

15 Amplifier Channels.

Magnetic modulator.

Oscillograph interchangeable Model 591 or Model 662.

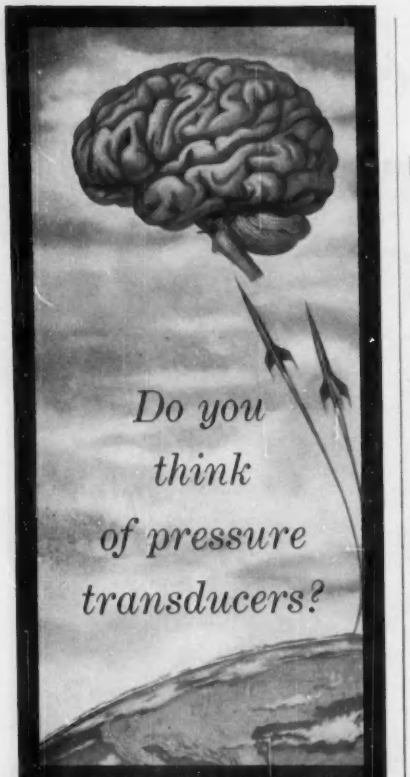
Amplifier characteristics:
- Input impedence 100,000 ohms
- Frequency Response:
  - Model 477 DC-300 cps
  - Model 478 DC-3000 cps
- Output power Model 477 Sufficient to deflect a MI 102-500 Galvanometer ± 2 inches
- Model 478 Sufficient to deflect a MI 102-3500 Galvanometer ± 2 inches
- Linearity 0.25%
- Input signal range 0.5 - 50 volts
- Drift and Gain stability: The sum of the drift and gain does not exceed ± 0.5% over the entire input signal range.

Scale Factor — Zero Offset Model 479 Manual or Programmed Adjustment in 256 equal steps.

Midwestern Instruments invites your consideration of MI designed, engineered and built Data Recording instruments and systems

MIDWESTERN INSTRUMENTS

41st & Sheridan Road • Tulsa, Oklahoma



Guided missile manufacturers do...

For example, the General Electric Missile and Ordnance Systems Department uses Statham Model PA203 pressure transducers on their missile programs. The Model PA203 miniature pressure transducer mounts into a ¾-16 fitting without zero shift from installation torque. The transducing element is the rugged Statham unbonded strain gage. This model is available in ranges from 0-5 to 0-1,000 psia and is constructed to the exacting standards of sophisticated customers.

WHEN THE NEED IS TO KNOW...FOR SURE SPECIFY STATHAM

Please request Bulletin No. PA203

Statham LABORATORIES

LOS ANGELES 64, CALIFORNIA

FEEDBACK

How to Set Up Control Systems Engineering

In July we received this letter from an instrument engineer in the midwest:

To the Editor—

We are considering the establishment of a "Systems Engineering Group", or equivalent, to make dynamic studies of process control systems with the aim of achieving better operation of present processes and improved design of new processes. This group should be able to make frequency response studies of process systems and components, study specific design problems that are encountered, and analyze the relative merits and economics of new instrument systems.

However, we have no experience in this type of work and are trying to ascertain exactly what is involved. Specifically we are interested in:

A. Organization of similar engineering groups.

B. Personnel required.

C. Training of personnel for this type of work.

D. Economic justification for establishing such a group.

E. Procedures, equipment, and time required for frequency response analyses.

F. Information and data that is presently available in this field.

We referred the man (now a subscriber) to these articles:

1. "How One Company Centralized Its Control Engineering", CtE Sept. '55, p. 63.

2. "A Way to Measure Pneumatic Component Dynamics", R. P. Bigliano, CtE, Aug. '56, p. 72.

3. "Organized Process Testing", E. W. James, CtE, Sept. '56, p. 169.

We pointed out that the entire contents of the Sept. '56 issue was devoted to explaining how to practice control systems engineering. We cautioned him that dynamic analysis is but one of the tools for analyzing control systems and that a well-organized control systems engineering group should include people with knowledge of machine and process operation, knowledge of measurement and control hardware, and knowledge of process economic environment, as well. The control systems engineering workshops at the ISA Conference Sept. 8 and 9 buttressed these pointers and added that the group should have a well-defined central responsibility.

This is not the whole story. The organization of personnel and the distribution of their work must vary with the industry and with the types of measurement and control problems encountered. Send us a description of how your group is set up, in whatever industry you practice. If your company does not have a recognized control systems engineering group, tell us how you think one should be organized. The best report on an existing group and the best essay on how one should be organized will receive awards of $10. Ed.

One for terminology buffs

To the Editor—

The July issue carried an item announcing Neptune Meter Co.'s revised Bulletin 566 under the heading, "Flowmeter Selection". As you probably know, Neptune meters are positive displacement meters, rather than flowmeters. Just thought I'd point this out because some of your readers are likely to be surprised when they get the bulletin.

K. L. Kline
W. L. Towne
New York City

If a positive-displacement meter is not a species of flowmeter, what is it? The usual p-d meter gives a total or integrated flow, but a dc tachometer attached to the meter spindle will produce a signal proportional to rate of flow. Fed to control equipment, this signal will control rate of flow. How would this differ from other types of flowmeters? It would certainly occupy the same block as other flowmeters in a control system diagram. Ed.

Stepping motor interests Germans

To the Editor—

We have been informed of an article in Control Engineering (Jan. '57, p. 74) concerning digital actuation of machines with stepping motors developed by the Teller Co. We would appreciate either more information on this development or contact with the Teller Co.

Dr. H. W. Wolff
Telefunken
Berlin, Germany

The article (we sent tear sheets to

How to Save Man Days in Research and Testing Involving Transients—**No. 3** *of a series*

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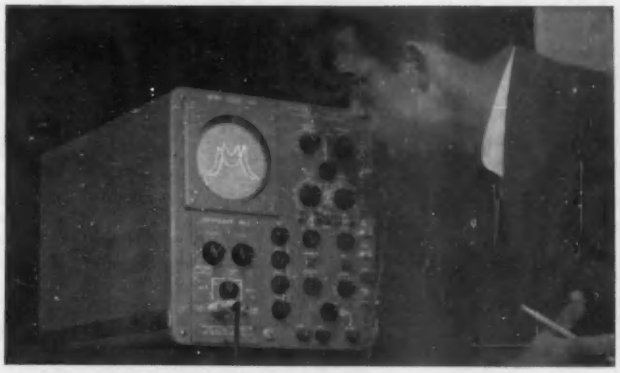
PROBLEM: Wave-form photography

Attempts at photographing elusive wave forms on conventional scopes have been, hitherto, a prodigious waste of time and film. Now, hair-trigger photography can be a thing of the past.

SOLUTION: a Hughes MEMO-SCOPE® Oscilloscope. What does the MEMO-SCOPE do that no other scope can? A storage-type oscilloscope, it can instantly "freeze" any number of selected traces *until intentionally erased.* Photos may thus be taken *at leisure*—with just one camera setting—one exposure—for each permanent record required. No tedious repetition. No more wasted film. The resultant savings can quickly pay for this "transient recorder with a memory."

If you haven't yet seen a demonstration of the MEMO-SCOPE *Oscilloscope, ask a Hughes representative to arrange one. He'll quickly do so—at your convenience—in your area. Please send for Application Data Sheets Nos. MSAD-A1 and MSAD-A2. Write to:*

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STORAGE TUBE—5-inch diameter Memotron® Direct Display Cathode Ray Storage Tube. Writing speed for storage: 125,000 inches per second. The optional Speed Enhancement Feature multiplies writing speed approximately four times.

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PREAMPLIFIER TYPE WB/4—Standard equipment with the described instrument. Frequency response: Vertical, DC to 250 KC down 3 db at 250 KC. Sensitivity: 10 millivolts to 50 volts per division (0.33") in 9 calibrated steps. Or, it is adjustable continuously with a 10:1 vernier.

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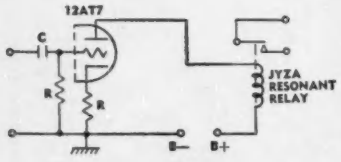
THE MARK OF QUALITY
BARBER COLMAN

ultra-sensitive relays

HELPFUL DATA FOR YOUR CIRCUITRY IDEA FILE . . .

(No. 7 in a series by Barber-Colman Company)

The circuit shown below indicates just one of the hundreds of ways many manufacturers utilize Barber-Colman ultra-sensitive relays to solve complex control problems. Could this be the answer to some of yours, too?

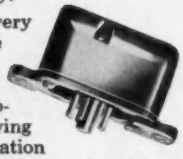


RESONANT RELAY USED AS OUTPUT ELEMENT TO PREAMPLIFIER

Unlike most resonant relays, the Barber-Colman JYZA may be used directly in the output of a high-gain vacuum tube without a coupling transformer to eliminate the d-c plate current from the input to the JYZA relay coil.

In other circuit variations, an auxiliary relay coupled with an R-C network will remain energized as long as the Barber-Colman resonant relay is operating. Also, a thyratron may be used in the contact circuit, to convert to an "on-off" signal.

The Barber-Colman JYZA resonant relay is characterized especially by its narrow band width and low operating power. At low frequencies, the required input is only 1.2 millivoltamperes and for higher frequencies this reduces to only 0.6 milliovoltampere. Coil impedance is high enough to be operated in the plate circuit of a vacuum tube without impedance matching devices. These relays can be supplied tuned to any frequency between 115 and 400 cps. Units have been built to resonate as low as 16⅔ cps. Band width varies from approximately plus or minus 0.5% to plus or minus 1% depending on input and calibrated frequency.



Because of the very sharp resonance available with Barber-Colman JYZA relays, applications involving signal discrimination are readily engineered, with a minimum of complex accessory equipment. Write for technical bulletin F-8311.

BARBER-COLMAN COMPANY
Dept. W, 1848 Rock Street, Rockford, Illinois

FEEDBACK

Dr. Wolff) explains how to size the motor for typical applications and presents performance data obtained from tests of several experimental units. The units will deliver speeds to 100,000 steps per minute and output torque to 3,000 in-lb. For additional information contact Arthur Fitch, president, Teller Co., Butler, Pa.

An AIEE paper presented at the East Central and Middle Eastern District Meeting and Air Transportation Conference, Dayton, May 7-9, '57, reports a similar product development. This is AIEE Paper No. DP 57-464, "A New Type Step Motor", by Samuel Noodleman, B. A. Wesche Electric Co. Ed.

Control science advances

To the Editor—

We have reviewed Eckman and Lefkowitz's article (Sept. '57, p. 197). This work is of a very much higher quality than the work I heard reported two years ago at a meeting of the Manufacturing Chemists Association. Both conceptually and in execution, this is a first rate job.

H. Grohskopf
American Cyanamid Co.
New York City

An important function of this magazine is to report on significant advances in the science and practice of control systems engineering. After following the progress of the Eckman-Lefkowitz project for a couple of years, it was clear to us that it had reached a state of maturity which warranted description to the broad spectrum of the magazine's readers. We, too, commend Eckman and Lefkowitz and urge our readers to hear their next report at the technical conference of the Instruments & Regulators Div. of ASME at the University of Delaware, April 2-4, '58. The report will concentrate on new work in optimizing transient control. Ed.

Clinic excites interest

To the Editor—

I was very interested in your report on the "Conceptual Clinic for New Instrumentation for Medicine and Biology" published in the August issue of Control Engineering, and should appreciate it very much if you could assist me in obtaining more detailed information on various topics which were discussed.

Roman K. Sas
Provincial Medical Physicist & Chartered Electrical Engineer
Durban, South Africa

We understand that the complete proceedings will be published either by the Foundation for Instrumentation, Education & Research or by the New England Institute for Medical Research. Write either Lloyd Slater, Executive Director of the Foundation (527 Lexington Ave., New York 17, N. Y.), or Dr. John Heller at the New England Institute (Ridgefield, Conn.) for a copy of the proceedings when they are available.

In addition to what CONTROL ENGINEERING reported, the clinic also dealt with diagnostic instrumentation. Topics included problems of instrumentation for 1) physical examination, 2) chemical analysis, 3) pediatrics—particularly a device to measure characteristics such as growth and texture of hair and fingernails, and one for cranial examination, 4) eye studies, 5) surgical instruments, 6) obstetrics. Throughout the meeting doctors indicated an interest in replacing X-ray techniques with diagnostic tools to reduce the amount of radiation a patient is subjected to in his lifetime. Ed.

Technical query from Egypt

To the Editor—

I am an instructor in the Faculty of Engineering at Alexandria University. I am going to be specialized in electrical instruments. Now I am preparing and studying for MSc in electrical instruments and my research is about "Alternating Current Potentiometers". I will be very pleased if you can help me to obtain catalogues or reviews about this subject.

Abd-El-Moneim Bilal
Alexandria University
Alexandria, Egypt

For bulletins and catalogs on electrical instruments, we suggest that you contact the directors of training of the instrument manufacturing companies; for instance, the Brown Instruments Div. of Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa. Brown has produced an excellent educational bulletin which teaches the principles of electrical instruments. You may

also wish to obtain a copy of "Servosystems Laboratory Manual", published by Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, N. Y., price $2. For other suggestions, see lists of bulletins used for in-plant training in "How Two Companies Train Technicians", CtE, Dec. '56, p. 65. Ed.

Ponders lot of laboring man

To the Editor—

I have just recently become acquainted with your publication, Control Engineering. Very much interested in the subject of automation and in particular the effect of such on the laboring man, I have followed the past Congressional hearings on the subject but wondered if you may have some current recent articles on the subject. I would be particularly anxious to have some recent work on the subject appearing either in your magazine or elsewhere, specifically dealing with labor's attitude and policies toward automation.

James A. Robinson
LCDR SC, USN
Palo Alto, Calif.

Industry's Pulse (Oct. 57, p. 59) dealt with one phase of labor-union reaction to the increased use of automatic production techniques—the campaign for the four-day week. "Labor Looks at Control" (Nov. '54, p. 17) summarized labor's opportunities at the beginning of '55 and "Did Reuther Speak for All Labor" (Feb. '55, p. 25) presented the attitudes of several union leaders. If you read these Pulses in chronological order, you will detect labor's growing welcome to automatic control—if labor can be said to have had a direct share.

For a broad view of the technical aspects, you might read a book entitled "Automation in Business and Industry" edited by E. M. Grabbe and published by John Wiley & Sons, Inc. The price is $10 per copy. Ed.

DDA not news? Some applications are

To the Editor—

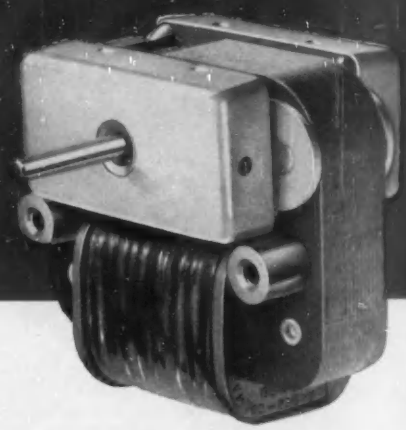
In the Sept. '57 issue of Control Engineering there were two articles in particular from which the following quotes are taken—"The fabulous DDA" (p. 26) and "The incremental computer" (p. 173). The articles gave the impression that these were new

THE MARK OF QUALITY

BARBER COLMAN

Unidirectional Small Motors

for your most critical applications where you need a good motor at an economical price



Model DYAB
with extra-large capacity oil cups

Leading manufacturers of top-quality products have found through years of experience that they can depend on Barber-Colman unidirectional motors to give long service with little attention. For example, several hundred thousand of the model shown above are in use in domestic refrigerators. After years of continuous operation *without relubrication* they are still performing perfectly. Other similar motors power office and vending machines, desk and heater fans, hair dryers, slide projectors, cooling fans, and blowers for electrical equipment. Many Barber-Colman motors are still in operation after 20 years of service. For dependable operation of your products, specify a Barber-Colman motor.

"PLUS" FEATURES OF HIGH-QUALITY BARBER-COLMAN UNIDIRECTIONAL MOTORS

Exceptionally high starting torque for quick, positive starting under adverse conditions

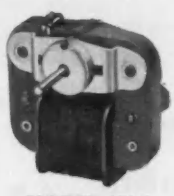
Generous oil reservoirs

Polished and ground stainless steel shafts which contribute to long bearing life under adverse conditions

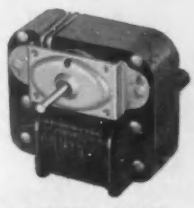
Various models — .00065 to .02 hp (full load)

NEW CATALOG
of unidirectional motors

gives you 12 pages of helpful data for selecting the exact motor needed for your application. Includes detailed illustrations, complete specifications, performance characteristics. Write for your copy.



MODEL YAA

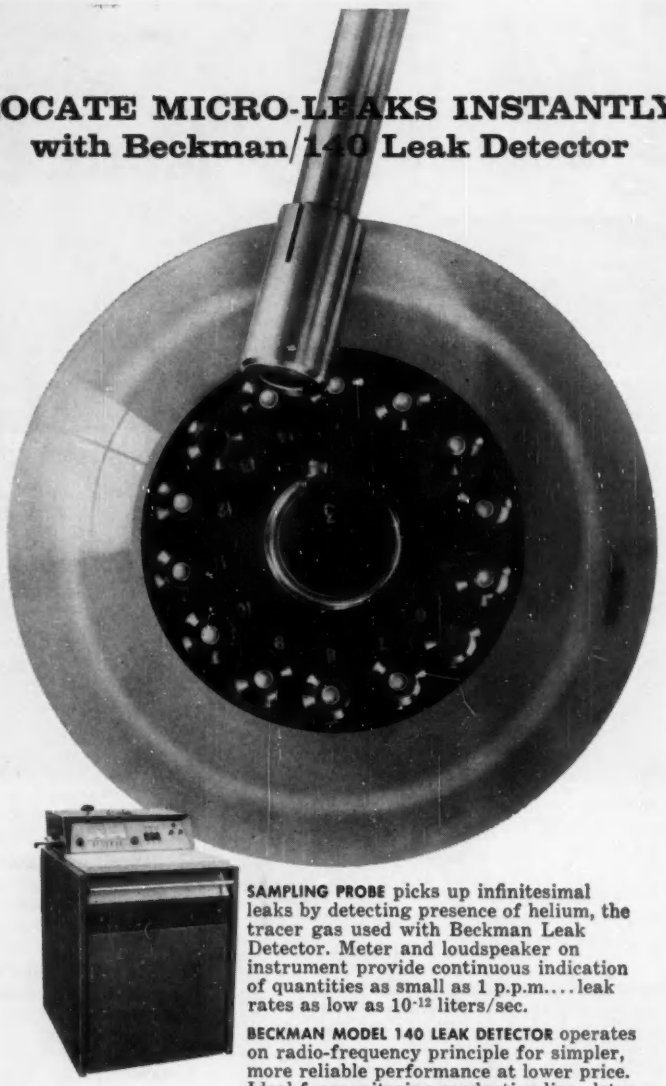


MODEL KYAF

BARBER-COLMAN COMPANY

Dept. W, 1248 Rock Street, Rockford, Illinois

LOCATE MICRO-LEAKS INSTANTLY
with Beckman/140 Leak Detector



SAMPLING PROBE picks up infinitesimal leaks by detecting presence of helium, the tracer gas used with Beckman Leak Detector. Meter and loudspeaker on instrument provide continuous indication of quantities as small as 1 p.p.m.... leak rates as low as 10^{-12} liters/sec.

BECKMAN MODEL 140 LEAK DETECTOR operates on radio-frequency principle for simpler, more reliable performance at lower price. Ideal for monitoring production line, determining porosity, guaranteeing shelf life.

Just one microscopic leak can mean failure of a hermetically-sealed, vacuum or pressure unit. It can mean more-than-microscopic leaks in your profits.

Beckman Model 140 Leak Detector rapidly detects leaks at rates as low as 1×10^{-12} liters/sec. Features include:

- Inert helium used as detecting agent—sensitivity of 1 part helium in 1 million parts air.
- Plug-in chassis provides minimum, easy maintenance.
- Integral packaging. Audible and visible indicators, work counter, and cold trap are all *built in—not accessories.*
- Immediate delivery from stock.

For more information about profit-protecting Beckman Leak Detectors, write for bulletin P-14-46.

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ELECTROLYTIC HYGROMETERS • FLOW COLORIMETERS • LEAK DETECTORS • OXYGEN ANALYZERS • DENSITY BALANCES

FEEDBACK

techniques; however, we at Litton Industries have been using these techniques for over two years. The Litton DDA's have been in production for almost two years and are in wide use throughout the country. The 20- and 40-integrator models are identical in size and weight. All the electronics, including power supply and magnetic drum, are enclosed in the computer.

Litton has built for the military several other computers using the incremental form of computation (DDA) and, I believe, we have built more computers of this type than any other single facility.

R. W. Rutishauser
Litton Industries
Beverly Hills, Calif.

In the sentence partially quoted by Mr. Rutishauser, head of Litton's Data Processing & Process Control Dept., we used the verb "was". We referred to tests last spring of a missile controlled by an airborne DDA. ARDC and the Pentagon checked the story for accuracy and security clearance. ARDC declined to tell about applications of the Litton DDA to flight control. The Air Force "has evolved its central computing concept around (the general purpose computer) . . . the DDA is being reserved for control applications that require only the solving of differential equations (such as inertial guidance systems in missiles)", to quote the continuation of the story on page 30. Ed.

Automated pajama game?

The May '57 Problem Forum (page 10) noted the need of A. C. Mason, Warwickshire, England, for a tape-controlled sewing machine. Here is a letter received by Mr. Mason—

You will undoubtedly be interested to know that we have partially developed just such a machine at Ohio State University. The machine uses punched tape and controls two-dimensional stitching. We are currently seeking a patent on the machine. The basic ideas have been proven and a demonstration model has been partially completed.

W. L. Starkey
Columbus, Ohio

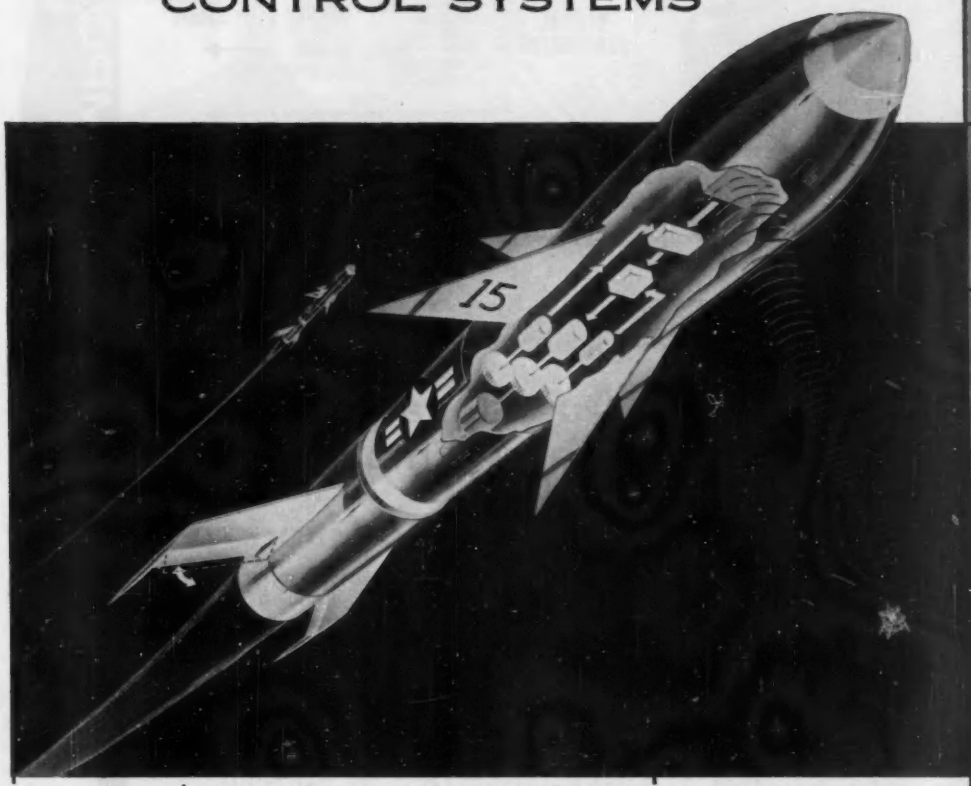
Mr. Starkey has since written us that the ownership of the patent rights has changed hands. He and Dean G. B. Carson of the College of Engineering, co-inventor of the machine, are working for approval of the new owners to describe it in CtE. Ed.

Simplify ordering and assure uniformly high quality of performance, with the advantage of Norden-Ketay's nationwide field engineering service. The following 6 pages describe modular units in Norden-Ketay's family of control components. You may use the coupon below to request literature on any units.

NORDEN-KETAY

CONTROL COMPONENTS

SIMPLIFY AUTOMATIC CONTROL SYSTEMS





Digital Comparators



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Gear Trains

Check numbers of bulletins desired.

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NAME_____ TITLE_____

COMPANY_____

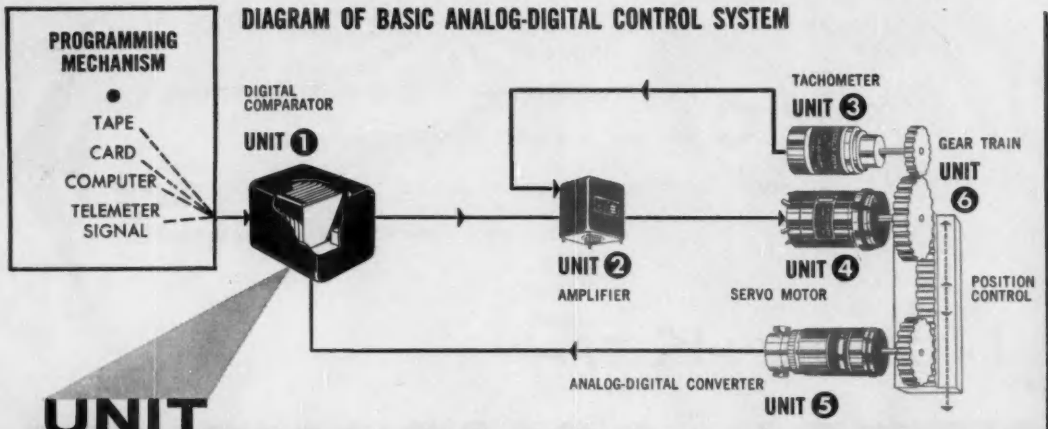
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CITY_____ STATE_____

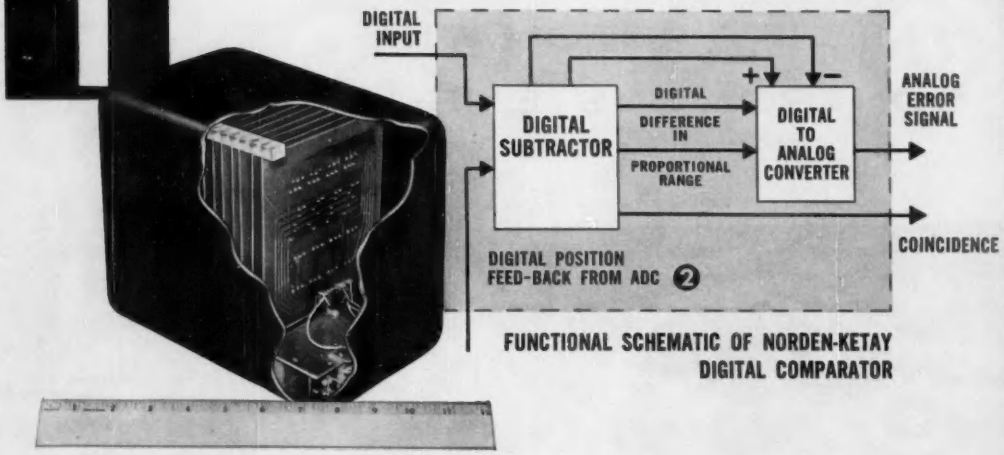
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UNIT 1 DIGITAL COMPARATOR



FUNCTIONAL SCHEMATIC OF NORDEN-KETAY DIGITAL COMPARATOR

New design permits true digital control with conventional servo motors and amplifiers

Norden-Ketay has packaged a new Digital Comparator that works with standard servo units to give servo systems the stability and reliability of digital control techniques. Used with N-K 13-bit and 19-bit analog-digital converters, the Digital Comparator simplifies circuitry and provides absolute reference by eliminating pulse counting.

In operation, a binary feedback signal indicating position of the controlled device is fed to the comparator by the ADC. This signal is compared with a parallel binary signal encoded from tape, cards, computer, or other command source. Lack of coincidence between the programmed and actual positions produces an error-modulated AC output. This signal indicates the magnitude and direction of the positional error and activates the servo motor to drive the device to coincidence.

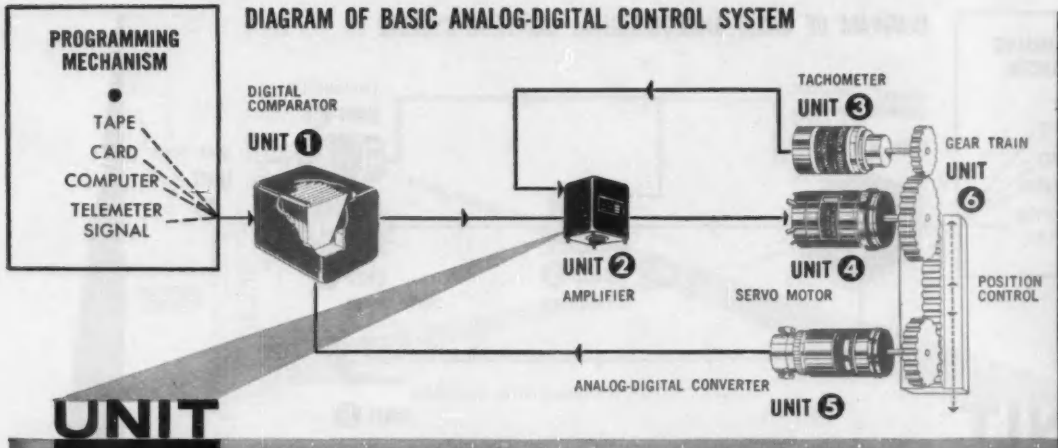
100% transistorized, printed circuit design eliminates tubes and relays, making possible a rugged package for severe environments, with great flexibility in range and configuration. By effectively bridging the gap between digital programming and analog control, the Digital Comparator opens up a wealth of possibilities for simplified solutions to difficult control problems.

Send coupon on page 17 for Bulletin #418 containing data on Digital Comparators. Norden-Ketay Corporation, Western Division, 13210 Crenshaw Boulevard, Gardena, California.

GENERAL SPECIFICATIONS

Weight: 10 lbs. Voltage req'd: −13, −11, +2 VDC; 115 VAC. Input: 13 and 19 bits. Output signal: 60 cps to 1000 cps.

N K NORDEN KETAY



UNIT 2 SERVO AMPLIFIERS



Wide choice of Norden-Ketay amplifiers permits exact matching of units with servo motors

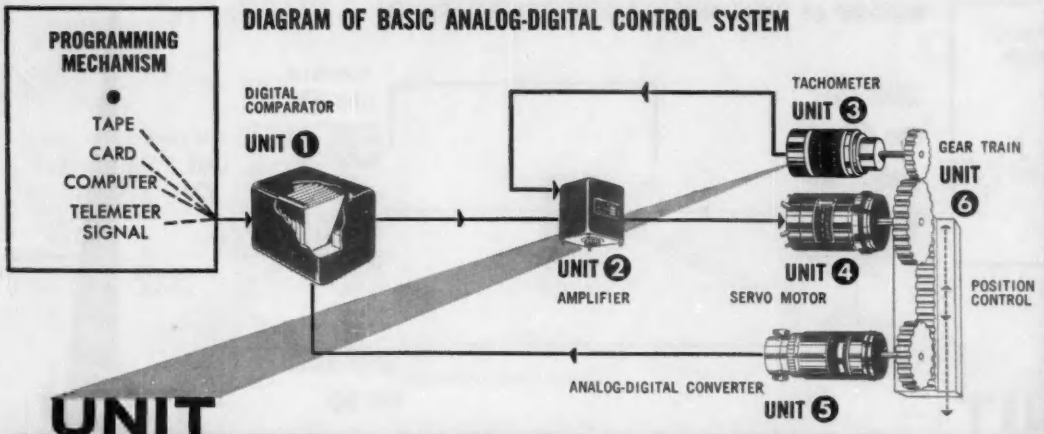
Servo amplifiers are available to drive the complete line of Norden-Ketay servo motors, varying from size 8 (1.75 watts, control phase) to size 23 (16 watts, control phase). High gain, low response time, and compact size are outstanding characteristics, resulting from the unique design features introduced by Norden-Ketay.

The standard selection includes amplifiers of electronic, magnetic, and transistor types. Transistorized resolver amplifiers, combined with N-K precision resolvers, can achieve overall system accuracy better than 0.07% from −55° to +110°C.

To broaden the system designer's field of operation, modifications of standard units are available to provide satisfactory operation over a wide range of ambient temperatures (−55°C to +125°C), and under adverse environmental conditions.

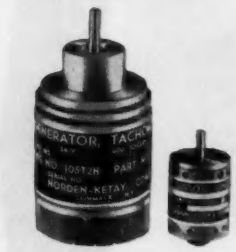
Where standard units do not meet your particular requirements, Norden-Ketay welcomes requests for the design of special amplifiers.

For Bulletin #382 with full information on amplifiers, send coupon on page 17 Norden-Ketay Corporation, Precision Components Division, Commack, Long Island, N.Y.



UNIT 3

TACHOMETERS



Variations can be specified in tachometer dimensions, voltages, frequency, shafts, and lubrication for extreme temperatures.



Tachometers present the designer with a new range of possibilities for control systems

Norden-Ketay offers tachometers designed for accurate computations and for use in velocity servo systems and stabilizing systems. Units are pre-aged to insure lifetime stable operating characteristics.

Norden-Ketay's integrating tachometers assure extremely accurate computations over a wide range of ambient temperatures.

The voltage output is pre-trimmed to ±0.2%, saving the systems engineer considerable time and money when installing a tachometer into a new system or replacing tachometers.

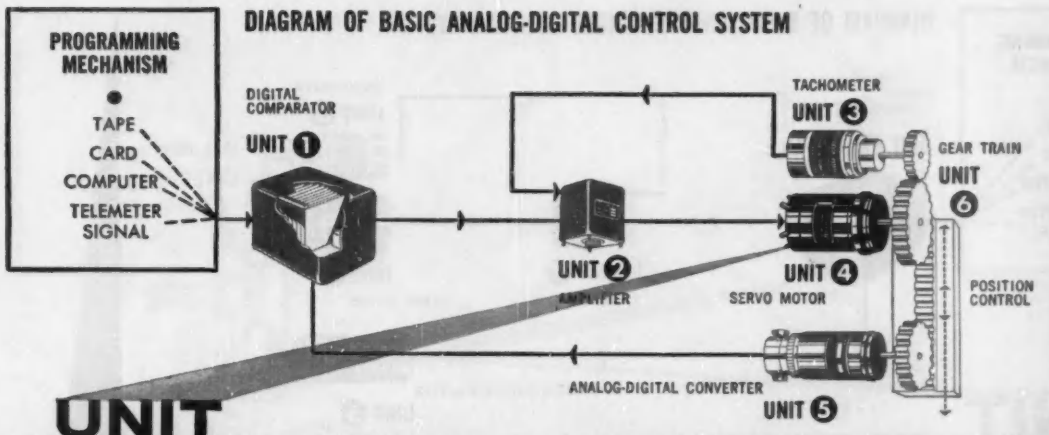
Linearity of ±0.12% of the voltage output at 3600 RPM from 0 to 4000 RPM. Temperature compensation holds output gradient to ±0.3% from —55° to +80°C. This compensation is done with a passive network which increases reliability, eliminates radio noise and phase shift problems that occur with a thermostat-controlled heater unit. Extremely high ratio of signal to in-phase fundamental null voltage of over 800 to 1. For extremely precise integration, a magnetic amplifier-controlled heater holds output gradient to ±0.02% over a temperature range of —55° to +80°C.

For damping tachometer purposes Norden-Ketay has improved the basic Mark 12 and Mark 16 types by providing internal features that insure greater reliability, stability, and lower null voltages.

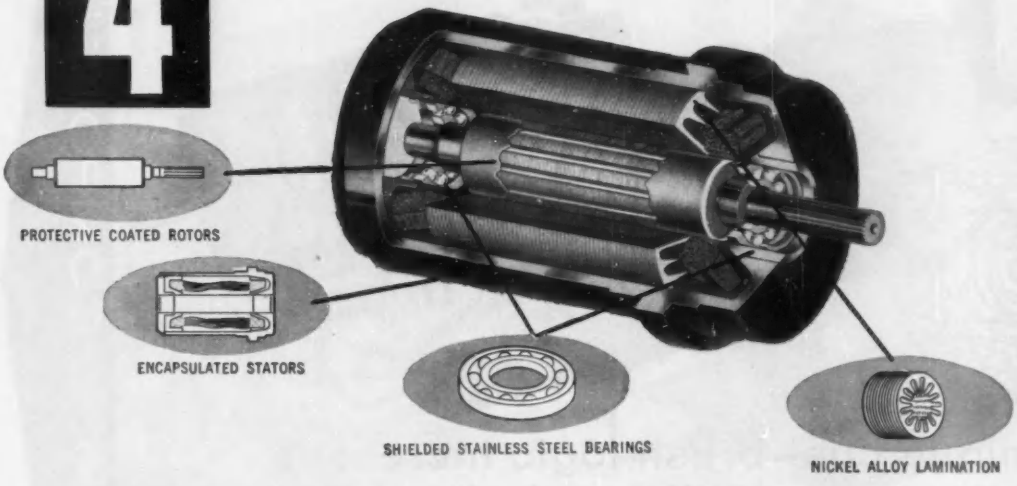
Send coupon on page 17 for Bulletin #423 containing data on wide selection of Tachometers. Norden-Ketay Corporation, Precision Components Division, Commack, Long Island, N.Y.

CONTROL COMPONENTS

N K
NORDEN KETAY



UNIT 4 SERVO MOTORS



High torque-to-inertia ratios of Norden-Ketay servo motors give fast, precise response

The ability to correct error rapidly and precisely in minute increments recommends Norden-Ketay servos for control systems where a combination of high torque and reliability are important. High acceleration, smooth performance at near-stall conditions, and operation at low control voltages assure fast, dynamic servo response.

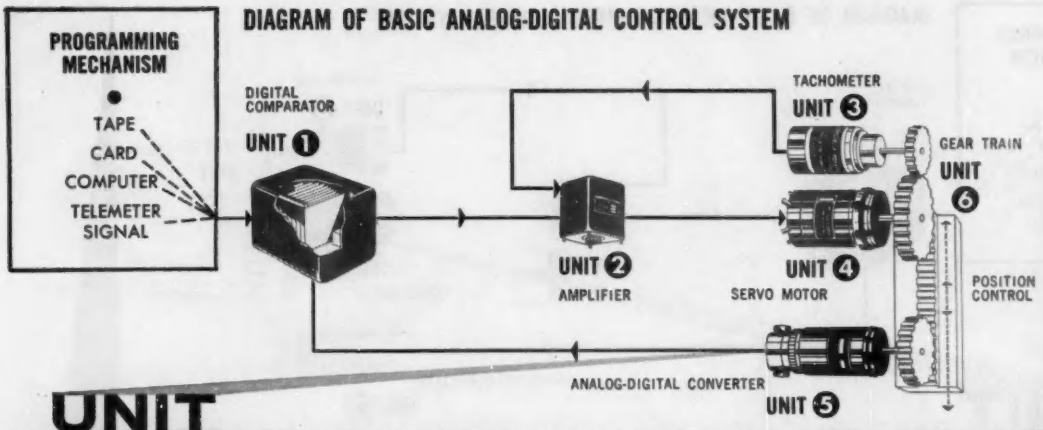
A complete range of sizes and types enables the designer to fill his requirements in size, characteristics, and special construction features with standard Norden-Ketay units. Diameters of .750″ (size 8) to 2.250″ (size 23) are available. Standard 400 cycle motors have stall torques varying from 0.25 to 7.0 inch-ounces, while 60 cycle units are rated from 1.45 to 7.0 inch-ounces.

Special design features in standard models provide a variety of shaft extensions and control voltages. Control phases can be driven directly from vacuum tube plates or from transistors. Units can be supplied with low input power requirements for the control phase, to control the performance of a relatively large motor.

Norden-Ketay servos can be combined with gear trains or tachometers to produce geared servomotors or geared servomotor-tachometer generators.

The availability of these design variations in a complete size range of standard motors simplifies system design, reduces component costs, and speeds delivery.

Send coupon on page 17 for Bulletin #385 containing data on Servo Motors. Norden-Ketay Corporation, Precision Components Division, Commack, Long Island, N.Y.



UNIT 5 DIGITAL CONVERTERS



Unique dual-brush logic increases system versatility and simplifies circuit design

Encoding of brush selection logic on the binary disc in the Norden-Ketay Analog Digital Converter (ADC) simplifies control systems by eliminating external circuitry otherwise required for unambiguous readout.

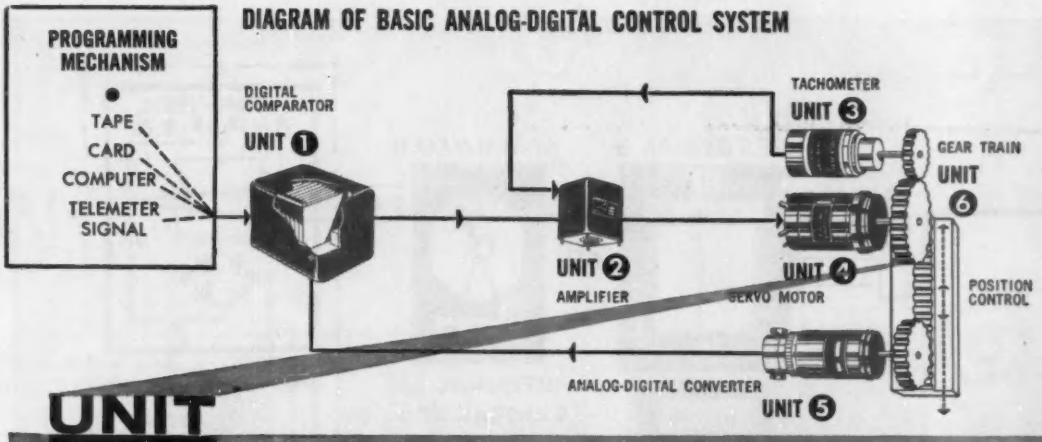
The simultaneous availability of both digit and complement allows two-directional operation with increasing count in both directions, simplifies subtraction and error-checking circuitry, and permits direct push-pull drive of bi-stable output networks.

The large digital capacity of the Converter provides sufficient digital increments to locate position and measure error with virtually any desired degree of precision up to one part in 524,288. This extreme precision is achieved without sacrifice of stability (as in the case of conventional analog systems) because of the positive on-off operation of the digital circuits, which are not subject to drift or noise-induced errors. The position indication is unique for every point. No errors can occur due to lost pulses, supply voltage transients, or even a power failure during which time the encoder position is changed.

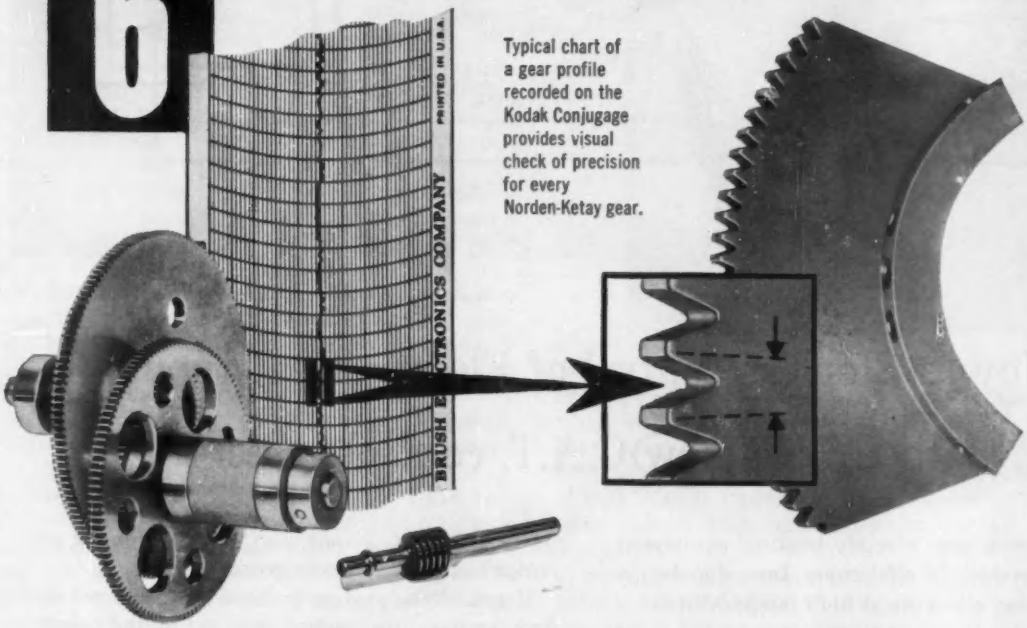
PERFORMANCE FEATURES

ADC-7-BNRY ADC-13-BNRY ADC-19-BNRY	Unambiguous, natural binary encoders, designed as airborne, multi-turn, digital servo components. 128 counts per turn; total ranges to 524,288 counts.
ADC-2-BCD ADC-3-BCD ADC-4-BCD	Unambiguous 8-4-2-1 binary-decimal encoders. 100 counts per turn; total counts of 2, 3, 4 decimal digits.
ADC-2B-16	Unambiguous, natural binary encoder with capacitance sensing of low-order digits. 2^{11} counts per turn; 2^{16} total counts, for guidance and control, antenna position digitalizing.

These ADC units meet military specifications. Cyclic binary encoders and other encoding devices for special applications can be ordered for particular requirements. *Send coupon on page 17 for Bulletin 372B containing data on Norden-Ketay Analog Digital Converters.* Norden-Ketay Corporation, Instrument & Systems Division, Milford, Conn.



UNIT 6 GEAR TRAINS



Typical chart of a gear profile recorded on the Kodak Conjugage provides visual check of precision for every Norden-Ketay gear.

Precision gear trains maintain high accuracy of servo systems to exact performance requirements

To maintain the high level of accuracy developed by Norden-Ketay components in control systems, the Florida Gear Division produces a full range of Gear Trains to precision tolerances.

With skills and facilities capable of cutting, shaving, and grinding gears from 3 to 200 D.P., to meet the exacting requirements of military specifications, Norden-Ketay has the precise answer to every gearing problem.

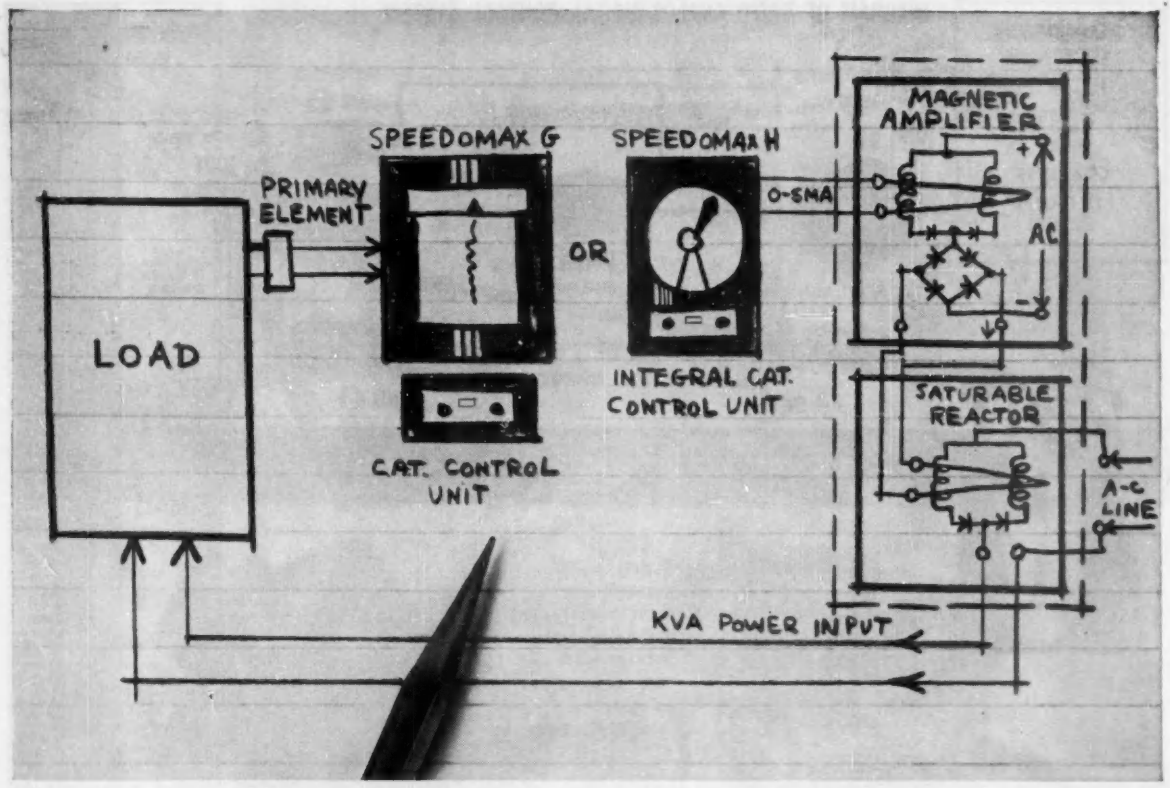
Extensive experience in gear engineering design for major military projects is an important asset of the Florida Gear Division in tailoring gear assemblies to the particular demands of high performance systems.

Application engineers are on call to go over your gearing requirement with a view toward obtaining the desired results with the simplest and most efficient gear combination.

Write to: Norden-Ketay Corporation, Florida Gear Division, Miami, Florida, or send coupon on page 17 for Capabilities and Facilities Bulletin #431.

CONTROL COMPONENTS

N K NORDEN KETAY



Now...Stepless control of Electric Heat Input with L&N's new C.A.T. control system

If your process uses electric heating equipment and your product is off-temperature due to cycling of heating elements at high temperatures . . . if excessive downtime and expensive replacement of worn-out contacts cut down production time . . . it'll pay you to learn about L&N's new Current-Adjusting Type control for continuous, efficient power output in saturable core reactor systems.

Already in use on applications like crystal growing and strip annealing, this control permits stepless regulation of power output over the *entire operating range of saturable core reactors.* Its rapid speed of response matches rapid changes in product temperature. The wide range of adjustment of proportional, reset and rate actions facilitates tuning the system to your process, product and production.

C.A.T. control is a complete system consisting of (1) a primary element, (2) Speedomax® recorder, (3) C.A.T. control unit, and (4) a magnetic amplifier and saturable core reactor.

Heart of the system is the C.A.T. control unit. Any temperature change, detected by the primary element and measured by the recorder, is fed to the control unit. Continuous d-c output of the unit over 0 to 5 ma range drives a magnetic amplifier. The d-c output of the magnetic amplifier is fed to the control windings of a saturable core reactor for continuous regulation of power input to the process.

If you're modernizing your present electric process equipment or installing new—make use of our wide experience in providing temperature control systems for thousands of applications. For more information, contact your nearest L&N sales office, or write us at 4918 Stenton Ave., Philadelphia 44, Penna. Ask for Data Sheet ND 46-33(107).

LEEDS & NORTHRUP
Instruments — Automatic Controls • Furnaces

RALPH SCHUMAN **updates machine tool control**

You would hardly expect to find a physicist in a machine tool builder's organization. But numerical control is changing the face of the machine tool industry, bringing in a variety of technical specialists, many of whom wouldn't have had a chance to practice their skills anywhere near a machine tool plant 20 years ago.

At Warner & Swasey, 80-year-old builder of turret lathes, control systems development and design is aided by Ralph Schuman, a physicist with a professional interest in systems engineering, and an outside predilection for power boats. Since he joined the machine tool builder in 1945, after a stint at MIT's Radiation Laboratory, Schuman has had ample opportunity to pursue both interests.

Contradicting the popular conception of a physicist—an ivory-towered theorist—Schuman dips a highly practical oar into W&S control designs. "The machine tool business is a highly competitive one," he points out. "That means you can use advanced sophisticated controls only when they are truly justified. Our customers buy machine tools to realize a profit from using them. The control system has to be geared to those specifications, too."

Today one of the top projects at Warner & Swasey is the study of the development of a numerical control system for a turret lathe, a problem aggravated by the functional complexities of this tool. According to Schuman, "The turret lathe represents a more complicated problem than a continuous milling machine because the lathe may use up to 10 sets of tools, and the cutters may be placed almost anywhere in respect to the turret.

"In addition, since the big advantage of the turret lathe is its flexibility, our numerical control system must make the operation automatic without sacrificing any of the machine's flexibility and versatility. Nor can it cost too much."

Schuman believes strongly that some designers of numerical control systems have substituted *what they can do for what they would like to do*. He sees a lack of reliable components—in particular, the lack of a good reliable encoder to convert shaft rotation into a digital signal—as the number one culprit. According to Schuman, encoders developed for the military can't meet the speed and life requirements of machine tool operations.

Schuman got into the control business almost by accident. After finishing high school he went to Miami University at Oxford, Ohio, "only for a year". Because he didn't plan to stay for a degree, he took the courses he liked best. But four years later he graduated with a BS degree and a three-way major in mathematics, physics, and chemistry. He then joined the faculty of the University of Minnesota, where he earned an MA in physics. When World War II started, he moved to MIT's Radiation Lab to work on the development of radar equipment



Away from machine tool control design work, Schuman is an avid user of machine tools as a do-it-yourselfer. His most ambitious project is the 21-ft power boat that he built over the past two years. Manned by himself and a crew of three (wife Eola, son Stephen and daughter Nancy), the ship has been exploring Lake Erie using the Schumans' home in Willowick as a base.

His boat is absolutely without electronics, because says Schuman, "they aren't needed". And this sums up his philosophy in applying electronics to machine tool control. "The machine tool industry has traditionally pounced on new developments and gone whole hog after them. First there was electrification; everything had to be electrified, whether it was justified or not. Then hydraulics came into fashion, and the same pattern evolved—hydraulics everywhere. Now it's electronics. But we're determined to use electronic gear only where necessary," says Schuman. That's why he feels his biggest contribution as W&S chief physicist has been "keeping the company out of electronics when it had no business being in it".

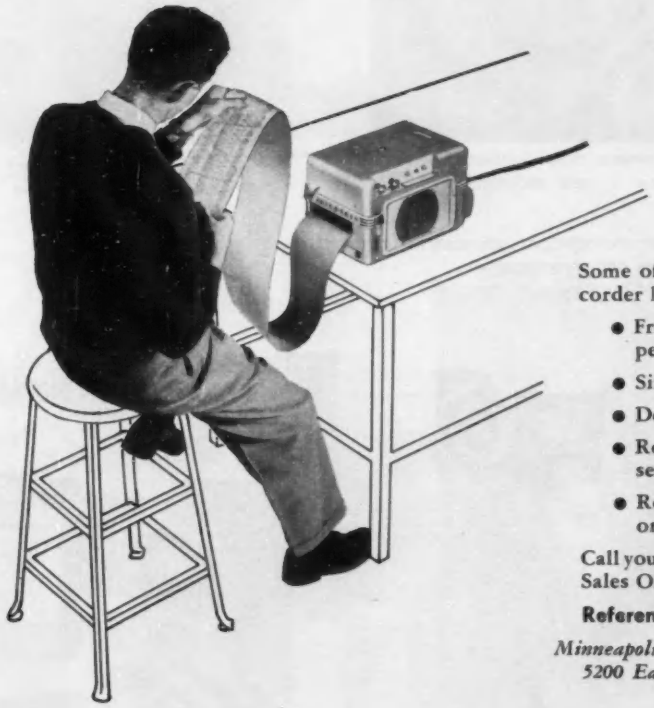
this is

This Visicorder Oscillograph record* is a symbol of the leadership that is typical of Honeywell engineering. In laboratories all over the world the Visicorder's instantly-readable direct records are showing the way to new advances in rocketry, control, computing, product design and component test and in nuclear research.

*reproduced actual size, unretouched

The Model 906 Visicorder is years ahead of the trend. It is the first oscillograph that combines the convenience of direct recording with the high frequencies and sensitivities of photographic-type instruments. The Visicorder alone among oscillographs lets you monitor high-speed variables as they go on the record.

a record of leadership



Some of the general features which give the Visicorder leadership in the direct-recording field are:

- Frequencies from DC to 2000 cps without peaked amplifiers or other compensation
- Six channels plus 2 timing traces on 6″ paper
- Deflection 6″ peak to peak; traces may overlap
- Record speeds 0.2, 1, 5, and 25 inches per second, minute, or hour
- Records require no liquids, powders, vapors, or other processing

Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin

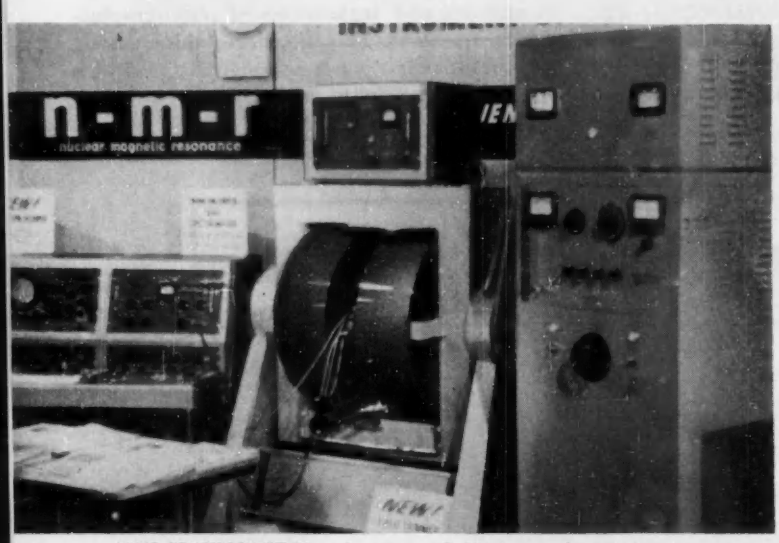
Minneapolis-Honeywell Regulator Co., Heiland Division, 5200 East Evans Avenue, Denver 22, Colorado.

MINNEAPOLIS **Honeywell**

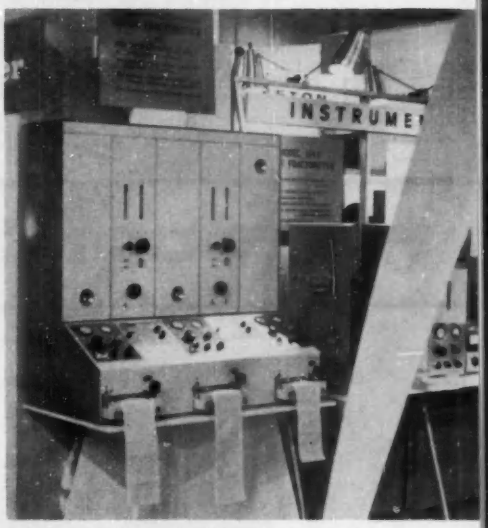
Heiland Division

A Control Engineer in Cleveland . . .

SEES ANALYSIS INSTRUMENTATION . . .

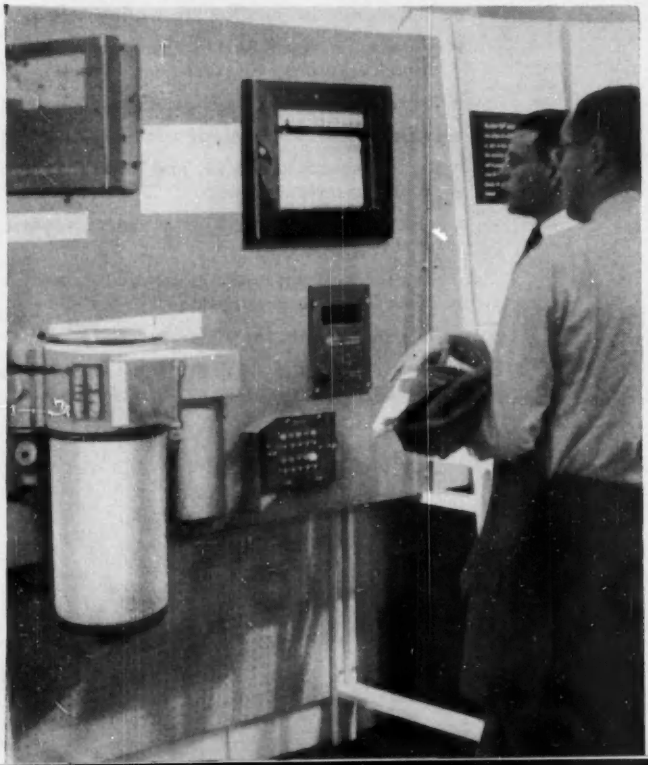


NMR SPECTROMETER and accessory field trimmer drew visitors to Varian Associates booth, indicating interest in new technique.



TRIPLE STAGE VAPOR fractometer was a highlight of the Perkin-Elmer display.

BELL-SHAPED explosion-proof container characterizes approach selected by Beckman Instruments for its gas chromatograph.





CHROMATOGRAPH built by Leeds & Northrup uses multi-bolted heavy box construction and senses with a hot-wire filament thermal conductivity detector.

. . . DATA HANDLING EQUIPMENT . . .



PINBOARD PROGRAMMING has been added to Fischer & Porter's data logger, opened up here as a salesman gave a visitor a closer inspection of the innards.



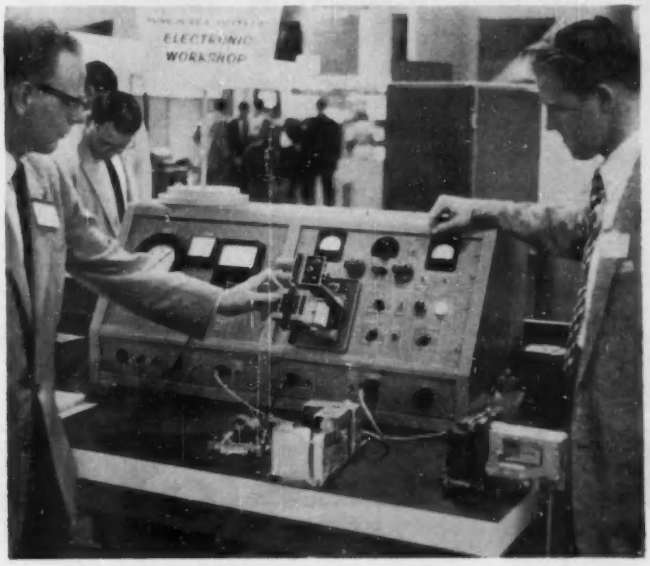
BECKMAN REPORTED sales of 13 installations of 112 data processing system (CtE, Oct. '57, p. 22).



BUILDING BLOCK DESIGN has been incorporated into Metrotype information systems, Bailey Meter pointed out dramatically.

. . . AND THE LATEST IN PROCESS CONTROL

ELECTRONIC WORKSHOP, developed to help instrument technicians calibrate electronic gear, was a Swartwout innovation.





ELECTROHYDRAULIC valve positioner introduced by Moog Valve Co. provides pump and sump in remote location (at left) for space saving.

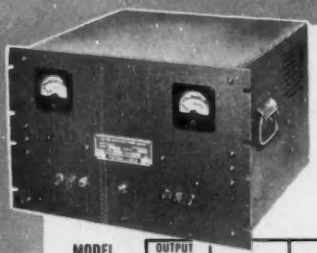
MORE ON THE ISA SHOW

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MODEL KR-16MC

1.5 Amp. KR SERIES

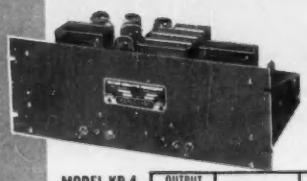
OUTPUT VOLTS DC	6.3V AC	Model	Rack Mount W	H	D	Price
0-150	Each supply	KR16	19"	12¼"	17"	$625
100-200	has two	KR17	19"	12¼"	17"	$625
195-325	15 Amp.	KR18	19"	12¼"	17"	$695
295-450	outputs	KR19	19"	12¼"	17"	$695

600 ma. KR SERIES



MODEL KR-8M

OUTPUT VOLTS DC	6.3V AC	Model	Rack Mount W	H	D	Price
0-150	Each supply	KR 8	19"	10½"	13"	$330
100-200	has two	KR 5	19"	10½"	13"	$240
195-325	10 Amp.	KR 6	19"	10½"	13"	$240
295-450	outputs	KR 7	19"	10½"	13"	$250



MODEL KR-4

300 ma. KR SERIES

OUTPUT VOLTS DC	6.3V AC	Model	Rack Mount W	H	D	Price
0-150	Each supply	KR 12	19"	7"	11"	$270
100-200	has two	KR 3	19"	7"	11"	$180
195-325	5 Amp.	KR 4	19"	7"	11"	$180
295-450	outputs	KR 10	19"	7"	11"	$190

125 ma. KR SERIES



MODEL KR-1C

OUTPUT VOLTS DC	6.3V AC	Model	Rack Mount W	H	D	Price
0-150	Each supply	KR 11	19"	7"	11"	$180
100-200	has one	KR 1	19"	7"	7½"	$ 90
195-325	3 Amp.	KR 2	19"	7"	7½"	$ 90
295-450	output	KR 9	19"	7"	7½"	$ 97

To include 3" Current and Voltage Meters, Add M to Model number (e.g. KR 16-M) and Add $30.00 to the Price.
To include Dust Cover and Handles for Table Mounting, Add C to Model number (e.g. KR16-C) and Add $10.00 to the Price.
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Kepco KR Voltage Regulated Power Supplies are conservatively rated and are designed for continuous duty at 50°C ambient.

REGULATION: Less than 0.2 volts for line fluctuation from 105-125 volts and less than 0.2 volts for load variation from 0 to maximum current.

RIPPLE: Less than 3 mv. rms.

STABILITY: The output voltage variation is less than the regulation specification for a period of 8 hours.

RECOVERY TIME: Less than 50 microseconds. The excursion in the output voltage during the recovery period is less than the regulation specification.

OUTPUT IMPEDANCE: Less than 0.1 ohms from 20 cycles to 100KC. Less than 0.5 ohms from DC to 20 cycles. Many units have very much lower output impedance.

featuring

- Fast recovery time, suitable for square wave pulsed loading.
- Voltage range continuously variable without switching.
- Either positive or negative may be grounded.
- Advanced vacuum tube regulator circuitry.
- Power requirements 105-125 volts, 50-65 cycles.
- Locking type voltage control AC, DC switches, fuses, and pilot lights.
- Terminations on rear of unit.
- Oil filled condensers.
- Color Grey Hammertone.
- Guarantee one year.

All models available for 400 cycle operation on special order.

SEND FOR BROCHURE B-574 — SPECIFICATIONS ON NEW MAGNETIC, TRANSISTOR AND TUBE VOLTAGE REGULATED POWER SUPPLIES AND SEMI-CONDUCTOR DC TO DC CONVERTERS

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ISA Show Plugs Process Control Gear

Innovations spark 1957 Instrument Society show in Cleveland as crowds disappoint. Management-oriented sessions meet mixed reception: the managers like it, the engineers don't.



TWO PROCESS PROBLEMS were posed to visitors at the Ramo-Wooldridge booth and solved by R-W's new process control computer which was on display for the first time.

Last September, in Cleveland's big lakeside auditorium, more than 500 manufacturers of instruments and process control devices showed off the newest and most up-to-date items in their product lines. The occasion: the 1957 Instrument-Automation Conference & Exhibit sponsored by ISA. The more than 80,000 sq ft of displays impressed leg-weary visitors first with the emphasis put on data handling equipment, and then with the show of a keener awareness of stream analysis instrumentation and an increasing concern over maintenance and reliability of process control hardware. Among the highlights:

▶ first public showing of Ramo-Wooldridge's process control computer (CtE, Sept. '57, p. 41) connected to a display board on which a visitor could change product inputs and outputs in a simulated chemical process to set the computer into action

▶ a new data-handling system developed by Minneapolis-Honeywell's Industrial Div. around a digital potentiometer (said to be so precise it can detect changes as small as one part in 4,000 in temperature, pressure, viscosity flow rate, vibration, or other variables)

▶ Bailey Meter Co. displayed for the first time a performance monitor (an on-line analog computer) that complements its line of Metrotype Information Systems equipment; the device uses servo-amplifier-type measuring equipment, slidewire and/or cam-actuated movable-core transformer-type retransmitters

▶ New plant gas chromatography equipment displayed by Beckman Instruments, Leeds & Northrup (both licensed a Union Carbide design but turned up with different end results), Consolidated Electrodynamics Corp., and Perkin-Elmer indicated rapidly growing acceptance of this analysis technique (CtE, July '57, p. 75)

▶ first showing of Nuclear Magnetic Resonance (NMR) equipment by Schlumberger Well Surveying Corp. and Varian Associates' Instrument Div. signaled interest in still another technique of analysis (CtE, June '57, p. 105)

▶ electronic workshop offered by Swartwout Co. to help plant instrument men calibrate and troubleshoot electronic devices that are working their way into instrumentation.

▶ transistorized test equipment built in modular design by CEC for increased reliability and flexibility and special transistor test equipment developed by Norden-Ketay

Although the exhibitors went all out to attract visitors—the lures included a bicycle-riding model niftily clad in Bermuda shorts, a talking dummy, a rocket-sled firing (every half-hour) and a two-story theater that cost $35,000 just to set up and which housed hourly lectures on systems engineering—the show failed to draw anywhere near the expected attendance. When the doors closed on Friday afternoon, the big counter by the main entrance showed only 18,500 registrants had passed through the turnstiles, compared to the "more than 30,000 attendance" confidently predicted by ISA officials.

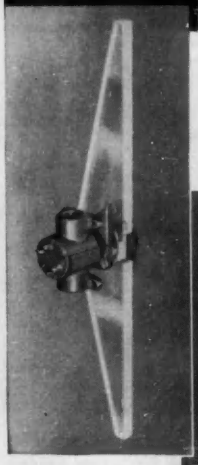
I. Around the Show

But for those who did attend, the exhibits contained a report-in-depth on the latest in process control. For example, the show offered an across-the-board view of automatic data-logging equipment. Bailey Meter claimed new life for its Metrotype Div. with an information system based on a building block design, introduced since Bailey purchased Metrotype from Hays. Bailey reports good commercial acceptance of the new design. It's already shipped two units —one to a government laboratory and one to a big chemical company—and has received orders for two more from electric utilities.

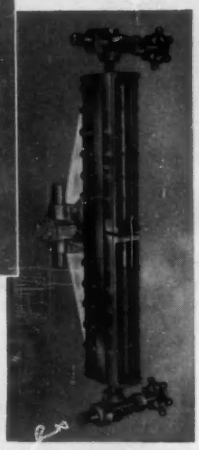
Fischer & Porter Co. has added pinboard programming to its automatic data logger to increase flexibility and make the equipment easier to use. Beckman Instruments' executives told those who visited its display of 112 Information Systems that the company has sold 13 installations in addition to the first one which started operating at Sweeney, Texas in October (CtE, Oct. '57, p. 26).

On display at the Daystrom booth was the first piece of hardware produced for the company's newly announced Operational Information

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ILLUMINATORS
FOR LIQUID LEVEL GAGES



No Glare



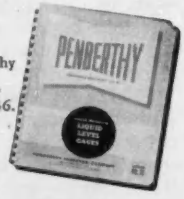
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Standard 15 watt bulb and electric wiring housed in aluminum casing. Adjustable brackets permit easy installation to gage cover. Approved by U.L.I. for electric lighting fixtures used in hazardous locations for Class 1, Groups C and D service.

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WHAT'S NEW

ISA Show . . .

STORY STARTS ON PAGE 31

System. The premiered product was ADIT (Analog-Digital Integrating Translater), said to differ from previous integrating systems in that the integrating function is within a closed feedback loop and the constant is not a determinant of calibration.

Other displays that contained automatic data logging gear were in the Minneapolis-Honeywell, Kybernetes, Gilmore Industries, Inc. and Taller & Cooper booths.

• **Stream analysers**—A keener interest in stream analysis instruments was evidenced by the number on display and the attention they received. By far the most popular equipment was gas chromatography, displayed at least five different booths. An interesting contrast was supplied by Beckman Instruments and Leeds & Northrup, both of which have licensed a gas chromatography design of Union Carbide Co. Neither commercial unit resembles the original design.

When Beckman purchased Watts Mfg. Co., which built the original equipment for Union Carbide, the West Coast instrument company redesigned the unit to satisfy a broader industrial demand. In the new design, the analyzer section has been installed with quick disconnect plumbing and electrical fittings to allow separating the hardware rapidly. Beckman claims that the explosion-proof bell-shaped container still permits fast accessibility to column and valve. The company offers a choice of two detectors, thermistor or hot wire. The thermistor unit is recommended for lower temperatures in the region of up to 110 deg C; the hot wire detector has been used up to 150 deg C and may be able to operate at even higher temperatures. The control unit affords rapid identification of the step the chromatograph is attempting and of the component being eluted.

L&N has also added some of its own ideas to the Union Carbide design: methods for easy standardization and calibration, plug-in programming units, and easy accessibility for maintenance. One point of argument in the L&N design is the multi-bolt, heavy-box construction which some viewers felt would slow up access; but the company feels the unit is so reliable that there will be little necessity for having to take the box apart. L&N claims that its hot-wire filament thermal conductivity detector allows the unit to handle higher temperature



TRANSISTOR TEST equipment displayed at Norden-Ketay Booth does five jobs.

samples and produce a full-scale output of 1 mv.

The CEC gas chromatograph, a third design, has been transistorized for increased reliability. It can handle the identification of four components in the stream.

• **NMR wins approval**—At the Schlumberger booth, where NMR equipment was being displayed for the first time, company spokesmen were pleased with the attention their equipment received. Varian Associates, which also displayed NMR equipment, reported heavy booth traffic too.

At the Swartwout Co.'s booth, the electronic workshop on display (price: about $1,000) indicated a trend toward the acceptance of electronic equipment in process control. The unit contained all the equipment an instrument technician would need to calibrate and troubleshoot electronic transmitters, panel components, and final elements. In addition, the workshop has an air supply for checking pneumatic power relays. The company also displayed a new two-pen recorder. By mounting two recorder units in tandem, the performance of two variables can be compared on a single sheet of recording paper.

Still another interesting innovation was a new electrohydraulic valve positioner displayed by Moog Valve Co. Its outstanding characteristic, according to Moog personnel, is its high resolution. It operates on a closed-loop servo system with mechanical feedback, and is remote from the pump and sump to save space.

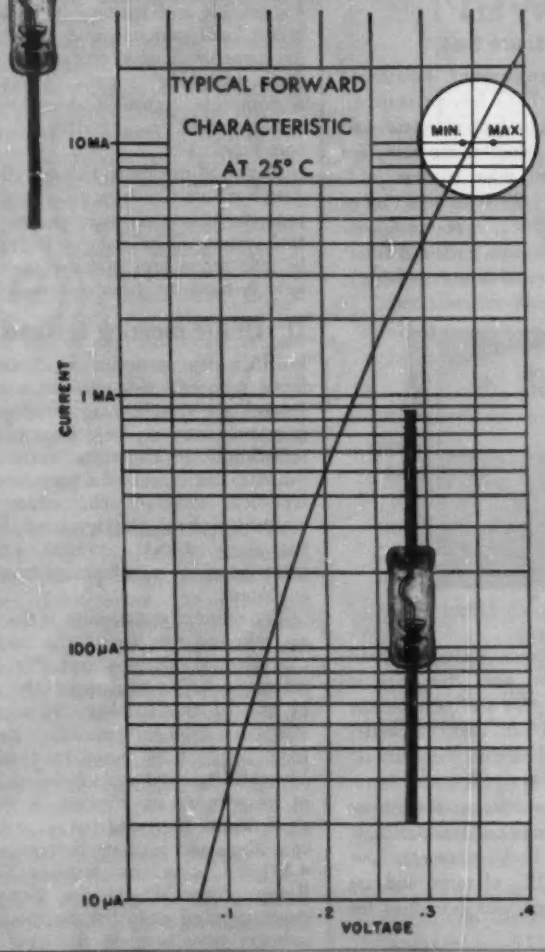
• **Off-the-floor displays**—Some of the most intriguing displays were missed by many visitors because they were held for limited audiences only in hotel suites. An unusually interesting one exhibited a new type ball relay which promises ultra-reliable relays, limit switches, and switching logic elements. The basic idea is to close a circuit between two conductors with

for circuits requiring utmost voltage economy

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Radio Receptor Germanium Diodes

10MA forward current with a maximum loss of only .37 volts!



DR 385	DR 434	DR 435

This extremely low controlled forward voltage drop combined with fast transient response makes these diodes ideal for transistorized circuits, computers and other applications where conservation of power is of prime importance.

Characteristics at 25° C

	DR 385	DR 434	DR 435
Forward voltage drop @ 10MA			
Minimum	0.34V	0.34V	0.34V
Maximum	0.37V	0.37V	0.37V
Maximum reverse current at −10V	10UA	10UA	10UA
Peak inverse voltage	60V	40V	30V

Maximum ratings at 25° C

Maximum inverse operating voltage	50V	30V	20V
Continuous DC forward current	100MA	100MA	100MA
Surge current for 1 second	500MA	500MA	500MA
Average power dissipation	80MW	80MW	80MW
Derating above 25° C	10MW/10°C	10MW/10°C	10MW/10°C

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RAMBLINGS ON INSTRUMENTATION

Manufacturers' Reps: How they get Human

Try as we might, we couldn't keep a note of quiet pride from sneaking into last month's "Ramblings", which related some eye-opening statistics about the qualifications of our manufacturers' representatives.

The profile of the typical Hays representative drawn by these figures reveals a guy with well above average qualifications in terms of education, experience and professional ability . . . a far cry from the commonly accepted stereotype of the "manufacturers' rep."

Well, while we're proud of the fact that the men who fly our flag are trustworthy, loyal, helpful, friendly, courteous, kind, obedient, cheerful, thrifty, brave, clean and reverent . . . they do have something else going for them, too.

This "something else" is Industrial Marketing Associates . . . or if you like to save time, simply "IMA". IMA is a congenial group of 10 non-competing manufacturers of allied equipment and 27 country-wide representative organizations banded together in a mutual assistance program designed to help us all be more helpful to customers.

IMA holds Regional Sales Refresher Courses for its members four times a year, each session lasting several days. The curriculum concerns products, installations, service techniques and new ideas.

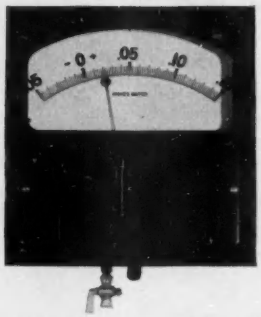
Besides a consistent educational program, IMA members (1) hold regional equipment shows, (2) coordinate exhibits and trade shows, (3) publish a product information magazine with 55,000 circulation (want to get it ? send me your name), (4) exchange information on profit sharing plans, salesmen's remuneration, billing procedures, etc., and (5) occasionally enjoy 19 holes of golf and good fellowship just to keep everything in its proper perspective.

So what ? *You, the customer* profit through being served by a nation-wide group whose local sales engineers can provide you with high caliber technical aid on an entire group of allied equipment.

Be glad to give you the name of your Hays representative!

Some Low-Pressure Sell

Our application engineering department tells us that Hays FOT low pressure direct acting diaphragm type indicators and OT low pressure recorders are being applied to more and more process jobs. Why ? Because (a) the wide selection of ranges we make (0-0.2" water minimum to 0-120" water maximum static and differential, two pointers and ranges available), (b) the readability of our indicator.



Try this, for instance. Unless the 5:18 is crowded tonight, hold this page at arm's length. Now you see the indicator as you would at 19 feet. That 0.2" water full scale range is less than the draft required to puff a filter tip! If you're interested in a continuous record those same ranges are available in our circular chart OT Recorder line. Both instruments have an accuracy of ±2% of range and are available with square root extractors for flow applications.

For further garnishment, send for our bulletin 56-350-16. That bulletin number again: 56-350-16. In the suburbs and for the recorder it's bulletin No. 57-232-25.

Phil Sprague Jr.

President

THE HAYS CORPORATION • MICHIGAN CITY, INDIANA

ISA SHOW . . .

STORY STARTS ON PAGE 31

a single ball or a multiplicity of balls made of a permeable material with a conductive coating. The balls, in a sealed container, are moved to close the contact by a stationary, low-power electromagnetic field or a moving permanent magnet, statistically presenting a new surface each time they are energized to reduce contact wear.

Developed by General Automation, Inc., these devices may solve two pressing industrial problems: 1) the need for reliable and reasonably-priced precision limit switches, and 2) the need for low-cost reliable output stages for static switching systems (There'll be a complete technical description of these devices in a forthcoming feature article.)

Both Minneapolis-Honeywell and The Foxboro Co. were soliciting opinions on new electronic process control systems. The data collected may be reflected in announcements of such new systems by these companies.

II. In the meeting sessions

ISA's new program of "management-oriented" sessions met a mixed reception. Most management people felt these sessions were extremely interesting, but engineers were disappointed and expressed a preference for technical sessions. The clinics and workshops held the weekend before the show started received, on the other hand, a lot of praise from the engineers.

The reduced registration at the show also affected the size of the audience at technical sessions but the small gatherings failed to dampen the ardor of any of the speakers. Key points stressed: a need for broadening the systems concept as basic to thinking; advocating digital techniques and use of computers in control; a greater awareness of the perturbation methods of analysis and learning by computers.

• **What's new in systems**—Simon Ramo (Ramo-Wooldridge vice-president) pointed out that business and industry pose tougher problems than the military because these two activities are more complicated. And he predicted that the pace for systems engineering in business and industry will be accelerated by such factors as the need for development of new products and the importance of percentage differences in profits between competitors.

Gordon Brown of MIT emphasized the broad aspects of systems

thinking, pointing out that instrumentation is a means to an end rather than the end itself. Brown analyzed differences between machines and human systems; he urged systems engineers to consider the form in which users ultimately want information.

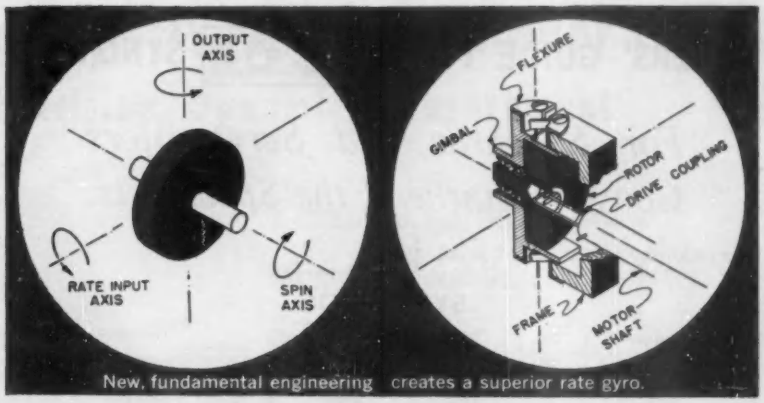
One of the highlights of the conference was the presentation by IBM's Cuthbert Hurd, which covered these topics: 1) computers and control, 2) reliability, 3) perturbation methods, and 4) learning. First he pointed out the importance of large-scale random storage. Then he explained the justification for using computers in control: computers do arithmetic because they can count; they can count because they can discriminate; discrimination is the key to deductive logic; and the solution of logic problems makes computers suitable for control.

Hurd also reported on the reliability of computer operations. The verdict: a mean free error path of 10 hours at 100,000 operations per second; or, stated another way, 3½ billion operations between errors.

The IBM vice-president encouraged the making of models by simulating processes and machines, pointing out that digital computers can be used to simulate, too. He urged the formal use of perturbation methods, as now used in physics, in control problems. Finally, he made the point that since no one knows enough about the systems to make a perfect model, it is important to build knowledge about the process and thus continuously improve the model.

• **From analysis to maintenance**—Case Institute's John Hrones discussed methods for analyzing processes from random disturbances. An economic slant to systems analysis was introduced by A. C. Brodie (Feedback Controls, Inc.) who said such analysis can give a price advantage in competitive bidding. Justification for analysis instrumentation was supplied by Harry Moore (Esso Research & Engineering Co.), who reported several instances where economic gains can be obtained by using stream analyzers. Improving a 20,000 barrel-per-day refinery operation by one octane number, he said, is equivalent to $2,000 more per day; and getting the product closer to flash measurement test specs results in a $400 savings per calendar day for each degree F improvement.

Responsibilities and objectives for maintenance were discussed by Neil Blair (Panellit Service Co.). Plan a program to meet objectives, he said; then establish procedures, administer the program, analyze results, and minimize costs. Among the objectives he listed were: safe operation, continuity of operation, quantity of product.



New, fundamental engineering creates a superior rate gyro.

New 'SW' Rate Gyro

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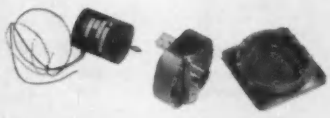
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BUYERS' GUIDE TO MUIRHEAD SYNCHROS

For Synchros and Servomotors Consult Muirhead the Specialists.

The following are in current production:

SYNCHROS

Designation	Size	Volts	Frequency	Function
26V08CX4(B)	08	26V	400c/s	Control Transmitter
26V08CT4(B)	08	26V	400c/s	Control Transformer
11CX4b	11	115V	400c/s	Control Transmitter
11CT4b	11	115V	400c/s	Control Transformer
11CDX4a	11	115V	400c/s	Control Differential Transmitter
11TR4a	11	115V	400c/s	Torque Receiver
11TX4a	11	115V	400c/s	Torque Transmitter
11RS4	11	26V	400c/s	Resolver
26V11CX4a	11	26V	400c/s	Control Transmitter
26V11CT4b	11	26V	400c/s	Control Transformer
26V11CDX4a	11	26V	400c/s	Control Differential Transmitter
26V11TR4a	11	26V	400c/s	Torque Receiver
26V11TX4a	11	26V	400c/s	Torque Transmitter
11 LINVAR	11			Linear Variometer
15CX4a	15	115V	400c/s	Control Transmitter
15CT4a	15	115V	400c/s	Control Transformer
15CDX4a	15	115V	400c/s	Control Differential Transmitter
15TR4a	15	115V	400c/s	Torque Receiver
15TR4b	15	115V	400c/s	Torque Receiver
15TX4a	15	115V	400c/s	Torque Transmitter
15TX4b	15	115V	400c/s	Torque Transmitter
15TDX4a	15	115V	400c/s	Torque Differential Transmitter
15TDR4a	15	115V	400c/s	Torque Differential Receiver
15RS4	15	40V	400c/s	Resolver
15CT6a	15	115V	60c/s	Control Transformer
18CX4a	18	115V	400c/s	Control Transmitter
18CT4a	18	115V	400c/s	Control Transformer
18CDX4a	18	115V	400c/s	Control Differential Transmitter
18TR4a	18	115V	400c/s	Torque Receiver
18TX4a	18	115V	400c/s	Torque Transmitter
18TDX4a	18	115V	400c/s	Torque Differential Transmitter
18TDR4a	18	115V	400c/s	Torque Differential Receiver
18CX6a	18	115V	60c/s	Control Transmitter
18CT6a	18	115V	60c/s	Control Transformer
18CDX6a	18	115V	60c/s	Control Differential Transmitter
18TR6a	18	115V	60c/s	Torque Receiver
18TX6a	18	115V	60c/s	Torque Transmitter
F18M-6-A/1	18	25V	1000c/s nominal	Resolver Transmitter

307/3

SERVOMOTORS

Designation	Size	Reference Phase Volts	Reference Phase Frequency	Control Phase Volts	Control Phase Frequency
Mk. 14 Mod. 2	11	115V	400c/s	115V (57·5+57·5)	400c/s
Mk. 14 Mod. 3	11	115V	400c/s	180V (90+90)	400c/s
*Mk. 14	11	115V	400c/s		
Mk. 7 Mod. 1	15	115V	400c/s	115V (57·5+57·5)	400c/s
Mk. 7	15	115V	400c/s	20V (10+10)	400c/s
*Mk. 7	15	115V	400c/s		
†Mk. 12 Mod. 0	15	115V	400c/s	115V (57·5+57·5)	400c/s
*†Mk. 12	15	115V	400c/s		
Mk. 8 Mod. 0	18	115V	400c/s	115V (57·5+57·5)	400c/s
Mk. 8 Mod. 1	18	115V	400c/s	115V (57·5+57·5)	400c/s
‡Mk. 8	18	115V	400c/s	20V (10+10)	400c/s
*‡Mk. 8	18	115V	400c/s		
†Mk. 16 Mod. 0	18	115V	400c/s	115V (57·5+57·5)	400c/s
*†Mk. 16	18	115V	400c/s		

TACHOGENERATOR Mk. 1 Mod. 1 Size 15 Energisation 115V 400c/s Output 3·2V/1000 r.p.m.

*Low impedance control windings †With Tachogenerator ‡Mod. 0 or Mod. 1 shafts

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If you require types not listed above, do not hesitate to send us your enquiry — they may be in hand — or, if not, we may be able to produce them for you quite quickly.

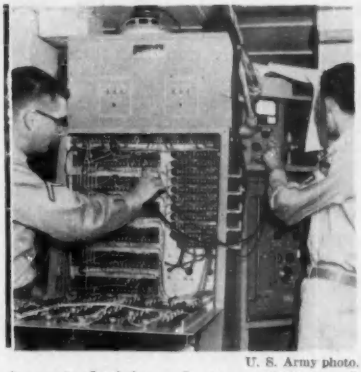
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WHAT'S NEW



U. S. Army photo.

Army technicians check out Minitrack equipment as . . .

Tracking Stations Ready For Satellite

SAVANNAH, GA.—

Throughout the world, the ten radio tracking stations that will keep tabs on the U.S.'s earth satellite are nearing completion. At Ft. Stewart, Ga., the Army's Corps of Engineers invited the press to take a look at the only station which the Army will operate in Continental U.S. (it will operate five in Central and South America, while the Navy will man one station in San Diego and another in Maryland; an eighth will be the joint responsibility of the Air Force and the Navy, and the ninth will be operated by Australian scientists).

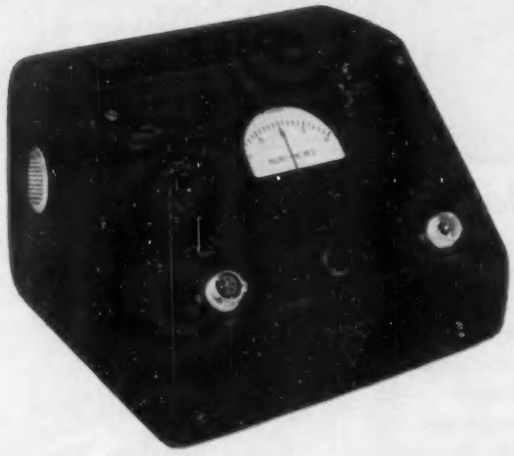
Heart of the Georgia tracking station is the Minitrack system (see photo above) which will detect and record signals emitted from the satellites as they pass over the station. Designed by the Naval Research Laboratory and built by Bendix Corp., Minitrack uses seven antennas to detect signals generated from sources in a "fan" of space over the station.

• **What's in the system**—Primary components of the equipment include: 1) a highly developed radio receiver which is extremely sensitive to signals of 108 megacycles, 2) a precision time section whose outputs are used to calibrate the system and to coordinate electronically the complex operations of the systems, 3) a phase comparison system that determines the angular position of the satellite using the interferometer principle (by measuring electronically the difference in time required for satellite transmissions to each of two ground stations), and 4) a readout section to supply 16 analog and digital representations of signals.

There's also a telemetry station to record parameters of environment re-

Industrial Electronics' DYNA-MYKE Model 129-E

High-Speed, Precision, Dynamic Measurement



A complete system for linear variable differential transformers and strain gages

- Single Unit Control System for LVDT's and Strain Gages
- Direct Reading of Static Displacements
- Provision for Dynamic Recording
- High Level, Low Impedance DC Output
- High-Speed Gaging and Control
- Universal System of Measurement

DYNA-MYKE is a high speed, precision, dynamic carrier amplifier micrometer. It supplies a complete measurement and control system for linear variable differential transformers and strain gages. Displacements as small as plus or minus one micro-inch at frequencies as high as 1000 cps can be detected and indicated. DYNA-MYKE carrier system energizes the transformers or strain gages at 8000 cps. Provision is made for balancing the carrier to mid-zero position on the meter. The modulated carrier may be fed into an oscilloscope; the demodulated signal into an indicator, recorder, relay, servo valve or servo-motor. The system of measurement is universal. Basic engineering phenomena such as force, torque, strain, vibration, acceleration, temperature, pressure, and displacement may be indicated and recorded, or used as a control function for high-speed automated applications.*

DYNA-MYKE is designed for use with commercially available pickups for measuring pressure, displacement, vibration and acceleration using linear variable differential transformers, strain gages, and inductive or resistive bridges as transducers. Custom pickups are designed and constructed by Industrial Electronics, Inc.

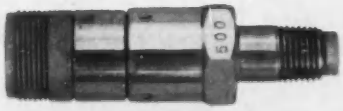
The light-weight, packaged unit is enclosed in an attractive, durable cast aluminum case.

**Ruggedized modular plug-in carrier systems conforming to Dyna-Myke specifications are also available for industrial plant installations. Write for information on company letterhead.*

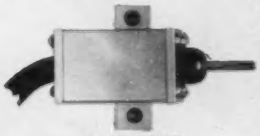
SPECIFICATIONS

Using Schaevitz 100ML LVDT: 2MV/V/.001 inch gage constant. 5 Ranges of Measurement 0.00001 inch to ± 0.1 inch full scale Sensitivity, Maximum—0.0000005 inch per meter division
System Frequency Response—DC to 1000 cps (down 3 db at 1500 cps.)
Carrier Frequency—8 kc, ± 2%
Carrier Voltage—Max 24 volts RMS, 20 volts RMS in 1000 ohms.
Maximum Gain, Overall 150,000 (RMS input to DC output)
Zero Drift, Maximum— ± 1% per hour after warmup
Instrument Stability— ± 2%
Repeatability of Measurement (Short time)— ± 0.5% or better
Output Current, Maximum Linear— ± 12 ma. in 1,500 ohms
Output Current, Maximum ungrounded— ± 35 ma. in 25 ohms
Output Impedance—450 ohms
Output Voltage, maximum (no load) ± 25 volts
Power—105 watts, 90-130 volts, 60 cps
Weight—22 lbs.
Dimensions—12¼ x 10 x 7½ inches

Calibration Signal Independent of Transducer Is Internally Provided.



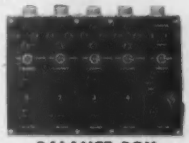
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ported by the satellite. This section uses a separate antenna system, a receiver system similar to that used in the Minitrack, and a transmitter which will command a tiny airborne tape recorder to play back what it has recorded on its previous trip around the globe.

To calibrate the system, passage of the satellite over the station is simulated by an airplane carrying a satellite transmitter. The plane also carries a high-intensity light which blinks on and off in a time code and which can be photographed at night by a camera equipped with a 20-in. lens. Comparing the photographs with the Minitrack recordings permits the crew to calibrate the stations' readings.

Worker Boredom Nipped at Automatic Bearing Plant

When Timken Roller Bearing Co. started operations in its completely mechanized bearing plant at Bucyrus, Ohio, one of the knottiest problems faced by management was how to keep monotony from sapping worker efficiency*. Machines were to do automatically many of the jobs that put variety into a man's workday in a conventional plant; the worker's role was to become one of a "machine overseer", making sure the machines produced products that met the specified tolerances. Many human operations became highly repetitive.

To solve the problem, Timken inaugurated a policy of rotating job assignments on a regular schedule. Most production machining operations at Bucyrus can be divided into green machining (on automatic screw machines), chamfering, face grinding, OD grinding, ID grinding, honing, and inspection. The company limits a man's stay in any one of these departments to three or four months. Then he moves to another department. In this way every worker gets a change of scene four or five times a year; and at the same time he gets different responsibilities, and a chance to work with different machines.

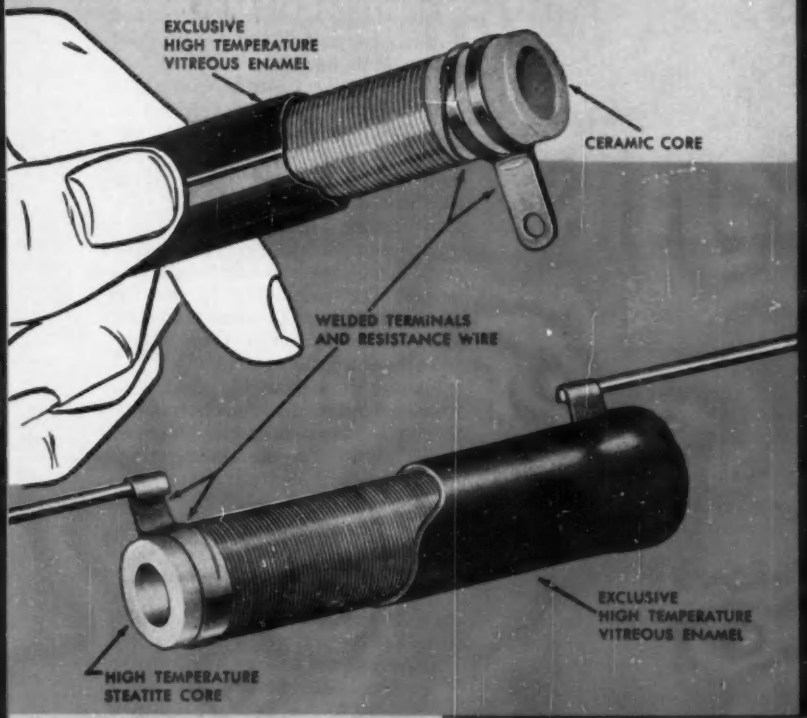
Timken goes a step farther in the

**The problem has given managements in a variety of industries a king-sized headache. In Europe, for example, workers bitterly oppose the introduction of automatic machinery because they fear monotony. The spectre of a workman going mad tightening bolts in an automatic factory—pictured by comedian Charlie Chaplin in the movie "Modern Times"—still haunts much of Europe's labor force.*

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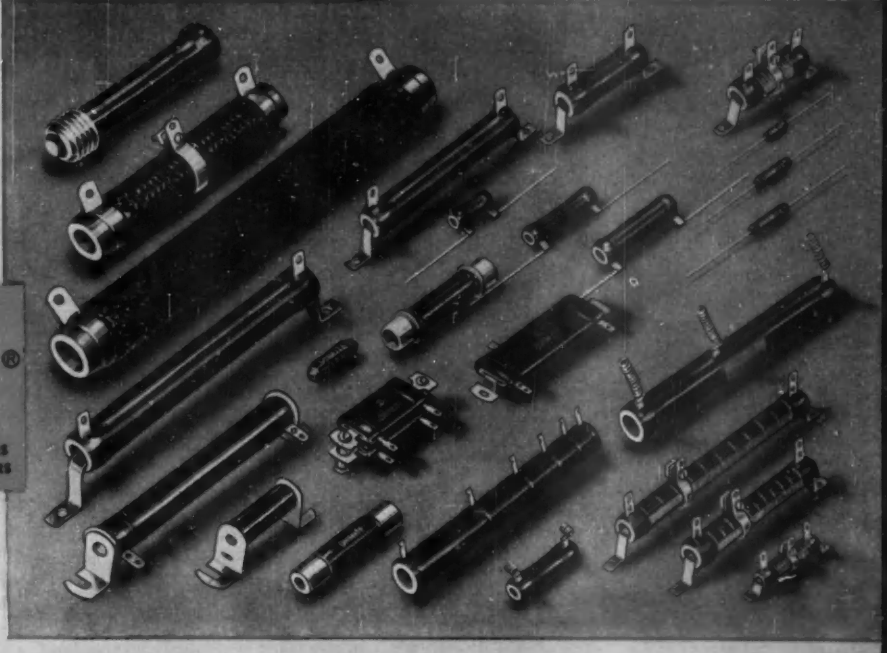
STRONG CERAMIC CORE This strong, rugged core has excellent electrical characteristics, and is unaffected by cold, heat fumes, or high humidity.

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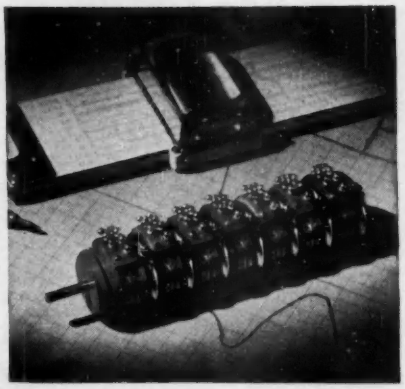
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final inspection work performed by female labor. To keep monotony from getting the upper hand, a girl is allowed to work at final inspection only four hours a day. When her four hours are completed, she moves to a different inspection assignment or another job, such as semi-automatic assembly of bearing cups, or packing.

Just how well the policy has worked in the five-plus years the plant has been operating is indicated by the low turnover rate and the long waiting list of applicants for jobs.

• **A look at the controls**—Completed over five years ago but opened for inspection for the first time this past September, the Bucyrus plant represents what control engineers might call the "first step" in designing the automatic factory. There's no sophisticated control equipment. The key to automatic operations is skillful mechanization of the techniques for moving bearing parts in process and in holding them while machining takes place—all without a hand operation.

Spotted throughout the plant is an occasional automatic inspection device (usually a Moore air gage). However, there's little "on-machine gaging" and no feedback control. Timken engineers considered feedback control of grinding machines, but rejected it as uneconomical for the plant.

• **The next step**—For Timken, the next step in plant design has already been taken. Many of the lessons learned at Bucyrus will be incorporated in a new railroad bearing line (capable of turning out automatically roller bearings up to 6 in. diameter) scheduled to start operation in January 1958 at Columbus, Ohio. From an instrument standpoint, the big innovation at Columbus will be more on-machine gaging.

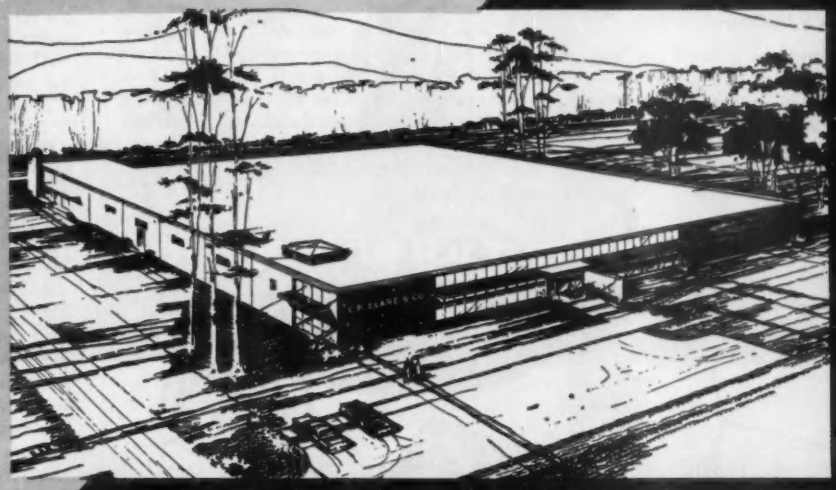
Balloon Floats Components in Environment Test

At the Autonetics Div. of North American Aviation, control engineers have borrowed a leaf from the balloonners' book for the environmental and functional testing of electromechanical components destined for guidance and control systems. Mounted in a metal-framed gondola, the components are carried to 90,000 ft by a 128-ft diameter, helium-filled balloon.

In this way, the engineers subject the components to the same temperature and pressure variations the equipment meets in actual operation in aircraft or air-breathing missiles.

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New C. P. Clare & Co. plant at Fairview, N. C. will expand manufacturing facilities which have been under way in Fairview for two years.

Before midyear 1958 CLARE will be serving customers from a new factory at Fairview, N. C.—a facility that will match the manufacturing advantages of our Chicago plant, itself only five years old.

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CLARE RELAYS

FIRST in the industrial field.



This relay may look like just another Sigma 11F, but this is not the case. It's the new 11F *with AC adjustment*. As such, it is the only AC relay available in the low price field that can boast such small size and all-around satisfactory performance within its ratings. This is why it sits so smugly at the top of the page, without even a headline.

It should be pointed out here and now that this relay is strictly an *on-off* deal . . . if you're looking for something fancier, Sigma probably has it (at a higher price). But, where you don't need the frills—in such items as water heater controls, tape recorders, and small battery-powered emergency lights used in restaurants, gambling casinos and federal penitentiaries—the 11F-ACS has no peer.

For the less technical-minded (who can't figure out the specs from the comprehensive application data above), the AC 11's have an operating level of 0.3 volt-ampere and will switch one ampere resistive loads at 28 VDC or 120 VAC. They are suitable for applications requiring UL Approval. Size, $1\frac{5}{32}$" square x 1" high, max. Price ranges from about $2.00 to $3.00 list in sample quantities (which *are* available), to about half that in quantities the designers dream about.



Packaging of the Series 11F relays is also an exclusive in the relay field. The relays fit snugly into specially designed molded foam layers which hold 25 or 50 relays apiece and stack neatly (i.e. the bottom of the top layer is the top of the bottom), eliminating the need for individual wrappers, fillers, boxes, bags, etc., and which might simplify inspection and assembly handling. The executives illustrated are *really* contemplating possible end-uses for these white foam layers. Suggestions so far include: raw material for making Christmas decorations, lawn ornaments, backyard toboggan runs, and a replacement for marshmallow fluff in peanut butter sandwiches. Any other constructive suggestions will be welcomed.

Inquiries about the 11F AC relay are also invited.

SIGMA

SIGMA INSTRUMENTS, INC., 69 Pearl Street, South Braintree 85, Massachusetts

WHAT'S NEW

Control Goes International

U.S.'s Harold Chestnut elected first president as hot French tempers scorch meeting of International Federation of Control.

Control engineers representing 19 nations gathered in Paris in September to tackle the unfamiliar chore of writing a constitution and setting up an organization for the much-discussed International Federation of Automatic Control. After three tedious days of negotiation, IFAC became a reality with a formally elected executive council presided over by the U.S.'s Harold Chestnut.

Since most of the organizational meeting was devoted to a rehash of the 45-article constitution previously prepared by the provisional committee established at Heidelberg, Germany (CtE, Dec. '56, p. 33 and July '57, p. 24), IFAC barely had time to get down to other business. Two major steps were taken, however: the group approved Geneva, Switzerland, as the permanent home of IFAC and set the first federation congress for Moscow, with the date still in doubt. Originally the congress was scheduled for 1960; however the U.S.'s John Lozier felt that this was too late and suggested a one-year advancement, which the Russians agreed to in principle but had to refer back to their government.

M. Anjbinder, Belgium representative, suggested that a series of smaller, highly specialized meetings dealing with various aspects of control be held prior to the big Moscow congress in 1959 (or 1960), the first to coincide with the 1958 Brussels World Fair. Details of such a meeting were left in the hands of the executive council.

The council was also given the go-ahead on the preparation of an international directory of leading control engineers and their work.

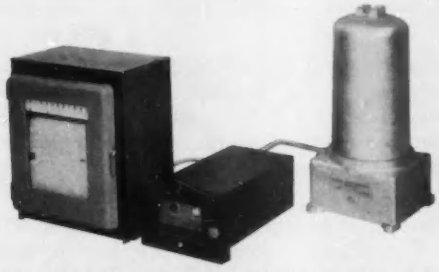
• **That French temperament**—Prior to the Paris meeting, there was some concern about possible Russian balkiness in IFAC. But the Russian representatives were models of cooperation, selling Moscow as the seat of the first conference like enthusiastic Chamber of Commerce members and distributing technical papers on Russian control accomplishments (particularly in the field of nonlinear systems). It was the host French delegation that turned out to be the organizing group's only headache. A dispute arose within the French delegation as to



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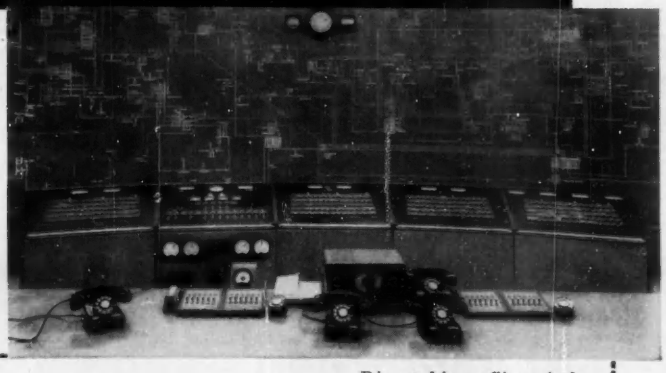
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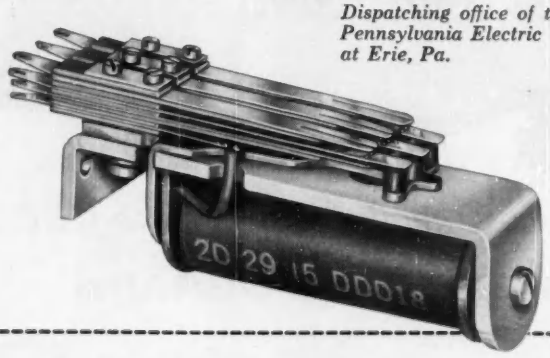
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WHAT'S NEW

who would be the country's nominee for second vice-president. When V. Broida was elected, the Association Francaise de Regulation et D'Automatisme threatened to secede from IFAC even before it was formally organized. And as the meeting ended, it was reported that AFRA would not support IFAC because of Broida's election.

This display of French temperament is another problem that will have to be solved by IFAC's newly elected officers. Besides Chestnut, who will hold the presidency of the executive council for two years, other officers elected are: A. M. Letov (USSR), first vice-president; V. Broida (France), second vice-president; G. Ruppel (Germany), secretary; and G. Lehmann (France), treasurer.

FIER Studies Graduate Courses in Control

The control industry will have a statistical picture of graduate education in the field when the Foundation for Instrumentation Education & Research completes its project, "A national survey of university graduate curricula and needs in the field of instrumentation". FIER hopes to tabulate detailed information on instrumentation and control graduate activity at 90 universities and colleges (not counting MIT and Case Institute, which were not included in the survey because FIER already has a full dossier on those schools).

In a preliminary report just issued, incorporating replies from 55 of the colleges, FIER found that automatic control techniques have already made a deep impression on college curricula. Other conclusions:

- 41 of the 55 respondents (to-date) reported that their schools offered graduate courses in the field of instrumentation and control.
- Most popular courses among students are those offering feedback control principles. Least popular were those that used advanced mathematics as tools of analysis and synthesis.
- One of the most fundamental subjects in all graduate curricula appears to be servomechanisms. Other subjects stressed computer technology, sampled-data systems, automatic control, and information theory.
- Help most frequently requested by colleges who would like to establish or strengthen graduate programs in the field is for "the financing of graduate student fellowships".

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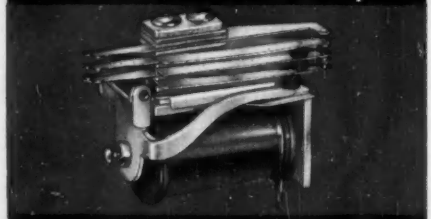
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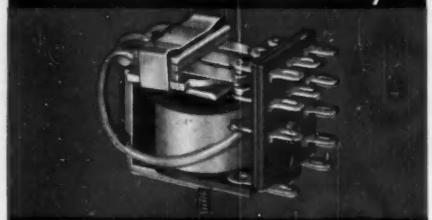




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EUROPEAN REPORT

Putting TFA to Work

Britain's Solartron Electronics Group, Ltd., has started a drive to introduce its transfer function analyzer (TFA), an instrument for testing servomechanisms, in the U. S. The company says it has Defense Dept. encouragement to bring its device to the attention of U. S. missile developers and producers.

Solartron claims that "TFA is the only servo test equipment which discriminates against noise and unwanted signals. It will measure almost every kind of servomechanism manufactured, detecting imperfections."

Solartron Vice-President Eric E. Jones says, "The device will speed up missile design and testing", and "there's nothing comparable to it in the U. S."

In addition to testing guided-missile servos, TFA is designed for both laboratory and production testing on fire-control systems, simulators and computers, magnetic amplifiers, aircraft engine vibration, autopilots, hydraulic servos, automation systems, and process controllers. It consists of a low-frequency decade oscillator and a low-frequency resolved components indicator. Combined frequency range is 0.1 cps to 1,000 cps for direct operation.

Price for Solartron's TFA ranges from $5,600 to $7,000. About 300 of the testing tools are already installed in Great Britain. Solartron feels the U. S. could use ten times that number of installations, in view of the broader missile development program in this country.

Sample units are already under study in the U. S. by Hughes, Bendix, Northrop, Convair, Boeing, Lockheed, North American Aviation, Dalmo Victor, General Electric, and Westinghouse.

Missile Components Nose Out the Planes in British Aircraft Show

Britain's new air policy, shifting from manned aircraft to unmanned missiles, was painfully obvious to airmen who attended the annual aircraft show at Farnborough, traditionally the unveiling place for new aircraft designs. At the 18th exhibition held in September, makers of components parts and equipment—350 strong—stole the show from the aircraft

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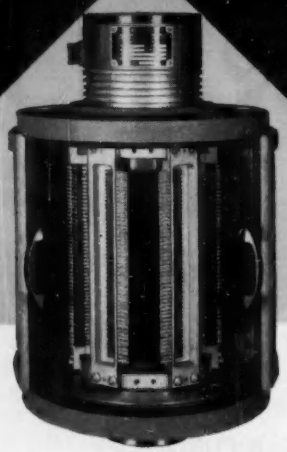
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Features:

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WHAT'S NEW

makers. And Minister of Supply Aubrey Jones pictured what's happening when he said, "The electronics industry is now playing a larger part in the manufacture of guided weapons than the aircraft industry."

This year's unveiling featured control components ranging from tiny accelerometers capable of resisting terrific g-forces to flight data systems. Among the innovations:

▶ phototransistor pickoff devices in an angular accelerometer designed by Elliott Bros. of London. A moving grid shutter illuminates two differentially connected photo transistors to measure the displacement of the rotor, which is proportional to angular displacement.

▶ electrical feedback to aircraft controls in a flight control system developed by Fairey Aviation Co. One uses a variable-feel device which takes electrical information of altitude and Mach number to control the stick force required per degree of movement.

▶ an aircraft flowmeter, claimed to be the first with fully automatic density correction, displayed by Firth Cleveland Instruments, Ltd. The correction is accomplished by a vibrating element in the form of a hollow chamber attached to a yoke by two hollow tubes. Fuel flows through the hollow chamber and tubes, which are maintained in oscillation at their resonant frequency by a thermionic oscillator. Changes in mass caused by density variations of the fuel passing through the chamber cause a change in resonant frequency which is used to correct the integrator unit.

▶ Two new methods of composite presentation of flight information, displayed by Elliott Bros. and Kelvin & Hughes, Ltd. In the Elliott system aerodynamic data brought to a central point from a capsule pressure transducer unit and a temperature unit feeds into an electromechanical computer with electric outputs for repeaters of altitude, indicated airspeed, Mach number, true airspeed, and vertical airspeed. The K&H system, developed with government support, incorporates two central sensing and computing systems. One is the aerodynamic reference system; it takes pressure and temperature inputs and computes them for presentation on two meters as indicated airspeed, Mach number, altitude, and rate of climb. The second system is the flight dynamic reference system; it provides attitude heading and ILS or Tacan positional information. —D. B.



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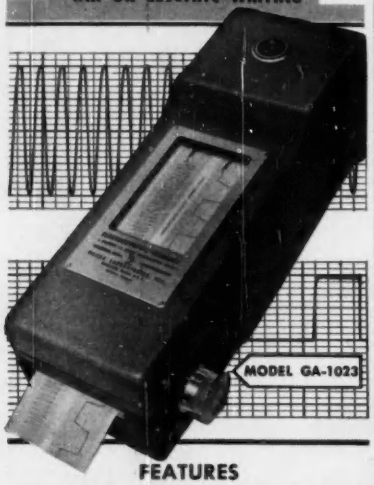
SYNCHRO FUNCTION	CPPC TYPE	ROTOR AS PRIMARY: Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	STATOR AS PRIMARY: Input Voltage (400~)	Input Current (Amps.)	Input Power (Watts)	Output Voltage (Volts)	Sensitivity (MV/deg.)	Phase Shift (deg. lead)	D.C. RESISTANCE: Rotor (Ohms)	Stator (Ohms)	IMPEDANCE: Zro (Ohms)	Zso (Ohms)	Zrs (Ohms)	Max. Null Voltage (MV)	Max. Error (Min.)
Torque Transmitter	CGC-8-A-1	26	.100	.5	11.8	206	8°	—	—	—	—	—	—	37	12	54 + j260	12 + j45	80 + j20	30	7
Control Transmitter	CTC-8-A-1	—	—	—	—	—	—	11.8	.090	.2	23.5	410	9°	150	24	212 + j684	22 + j115	246 + j60	30	7
Control Transformer	CTC-8-A-4	—	—	—	—	—	—	11.8	.029	.08	22.5	390	8°	389	64	560 + j1860	90 + j340	640 + j190	30	7
Torque Receiver	CRC-8-A-1	26	.100	.5	11.8	206	8°	—	—	—	—	—	—	37	12	54 + j260	12 + j45	80 + j20	30	30 up.
Electrical Resolver	CSC-8-A-1	26	.038	.42	10.8	190	20°	11.8	.078	.26	23.2	400	11°	230	27	286 + j620	45 + j148	350 + j75	30	7
Electrical Resolver	CSC-8-A-4	26	.038	.42	26	454	20°	26	.030	.23	21.5	375	12°	230	170	286 + j620	250 + j830	350 + j75	30	7
Control Differential	CDC-8-A-1	—	—	—	—	—	—	11.8	.085	.21	11.8	206	9°	36	25	38 + j122	27 + j120	48 + j14	30	7
Vector Resolver	CVC-8-A-1	26	.057	.34	11.8	206	10.2°	—	—	—	—	—	—	78	27	103 + j440	8 + j30		30	7

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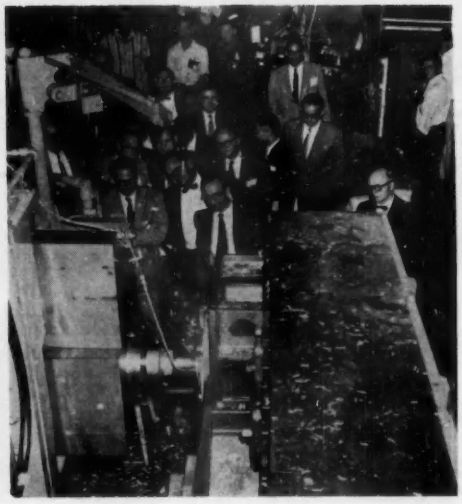
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NUMIL (its transistorized control console in foreground) performed at North American Aviation, profiling jig and fixture parts.

K & T profile miller with Bendix control held the audience's attention as it sent chips flying at Northrop Aircraft Co.

Numerical Control in Action at EIA Meeting

There was no question as to what was the highlight of the technical symposium on numerical control systems for machine tools sponsored by Electronic Industries Association (now EIA but formerly RETMA) in Los Angeles, last September 17 and 18. In-plant demonstrations of numerically controlled machine tools drew packed crowds. In fact, Northrop Aircraft had to schedule three separate performances of its numerically controlled K&T profiling mill (see picture above) to accommodate all the EIA visitors who wanted to see the machine in operation.

Interest was sparked for the meeting by the initial deliveries of numerically controlled machine tools to the aircraft industry as part of the U.S. Air Force's Air Materiel Command's tool modernization program. As a result, a large number of production engineers who will actually work with the tools attended the symposium.

• **Cutback threat**—With Air Force purchases supplying some of the steam behind the symposium, it was no sur-

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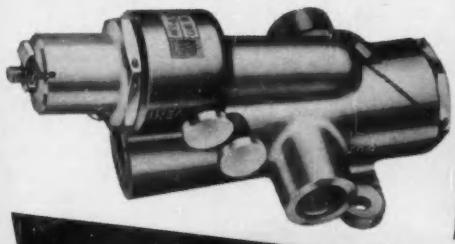
SPECIFICATIONS

Inlet Pressure—3000 psi
Rated Flow—Up to 75 lbs/min. (1000 SCFM)
Outlet Pressure—As required—200 to 2800 psi
Relief Pressure—115% of Outlet Pressure
Maximum Leakage—5 c.c./min standard air
Ports—½ inch tube size
Temperature Range— —65° to 180° F
Overall Dimensions—6.85 x 3.5 x 3.4 inches
Weight—1.87 lbs.

Endurance tested for 100,000 cycles. Integral bleed-down feature releases outlet pressure when inlet pressure is removed.

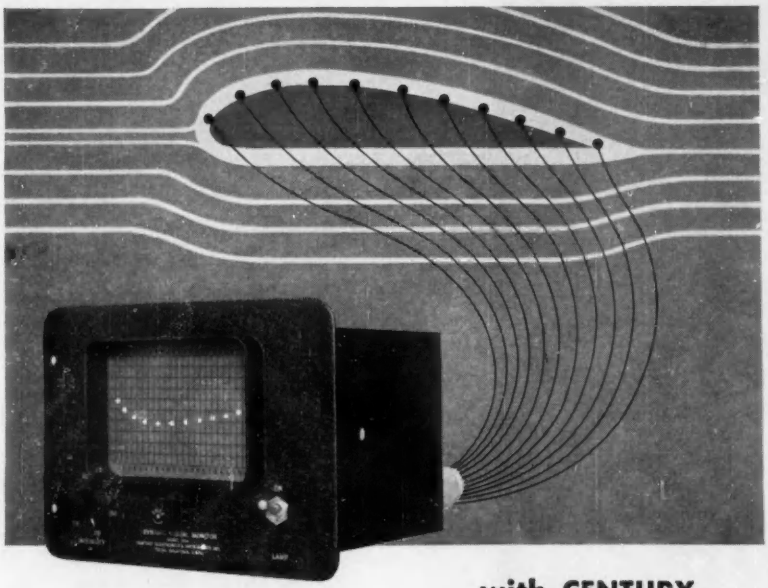
Weston Reducers feature close control of outlet pressure over a wide range of inlet pressures and outlet flows. Performance exceeds the requirements of specification MIL-R-8572A (Aer.). Designs are presently available with flow capacities up to 2000 SCFM! We invite your solicitation with reference to specific application.

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SEE and MEASURE pressure distribution



with CENTURY Model 20 VISUAL MONITOR

Visual presentation of airfoil pressure distribution is achieved by a major airframe manufacturer by means of the Century Model 20 Dynamic Visual Monitor.

By dynamic bargraph display, simultaneous observation of 24 pressure-transduced signals is permitted throughout an extended range of frequencies. Variations in pressure gradient, peak pressures, as well as oscillations associated with sonic flow phenomena are thus presented in continuous analog form.

Information presented by the Monitor permits a high degree of selection of those data for permanent recording by conventional tape or recording oscillograph process. With such discretion available, the great savings in data reduction time becomes apparent.

The Monitor provides a display of the focused light beam from as many as 24 pencil-type galvanometers on a calibrated viewing screen, 2.5" high x 4.0" wide. Galvanometers, flat in range of 0 to 42 cps with sufficient deflection sensitivity for direct coupling to most transducers are available. Other galvanometers are available for use in the region of 0 to 240 cps.

Monitoring of temperatures throughout a system or along a given piece of material, monitoring of vibration, flow, colorimetry and current are also vital applications of the Monitor.

Century Electronics & Instruments, Inc.

1333 No. Utica, Tulsa, Oklahoma

WHAT'S NEW

prise to find that the first speaker was the Air Force's Lt. Gen. C. S. Irvine, deputy chief of staff for materiel. Irvine's opinion of numerical control was crystal clear. He said that the Air Force expects to achieve significant production economies by the introduction of such systems into the aircraft industry. Not so clear, however, was how the Air Force's current economy drive would affect the numerical control program. Rumors of serious cutbacks in tool purchases kept the symposium buzzing.

The cutback threat added significance to the symposium's discussion of data processing problems in connection with numerical control. Seeing some of their aircraft market dissolving, the machine tool builders are anxious to develop new prospective customers for taped-control machines in other industries. And the builders think that expensive data processing equipment may be one hurdle commercial buyers won't jump.

• **Simplicity**—As a result the machine tool industry now agrees that "the simpler the data processing system, the better". To prove simplicity of its Digimatic system, Electronic Control Systems, Inc. had a machinist describe for the symposium how to prepare control tapes from a blueprint.

A good portion of the symposium was devoted to a technical description of six control systems. The six were: Giddings and Lewis' Numericord, Electronic Control System's Digimatic, Cincinnatti Milling Machine's newly-named Digilog, and Bullard Co., Bendix Aviation Corp. and General Electric systems. Control engineers had heard much of this before (CtE, Jan. '57, p. 20).

E. E. Kirkham, Pratt & Whitney Co., evoked an unusual amount of interest with a paper that surveyed the field of numerical control outside AMC's program. He covered the established systems and those which will soon be available here and in Europe, including point-positioning systems (in which area Kirkham acknowledged an assist from CtE editor John Cooney).

• **The bulls have it**—One conclusion that most visitors to the symposium reached was that both control manufacturers and machine tool builders are "bullish" on numerical control. One control manufacturer representative said, "The first year of operation in the aircraft industry will establish real proof of the value of numerical control, and will drastically change industry's view toward this concept."

—M. M.

Allied's New MHJ Relay

Built for Shock and Vibration

10–55 cps at 0.125 inch double-amplitude • 55–2000 cps at 20g

Here are the facts:

Contact Ratings:
Low level up to 2 amperes non-inductive or 1 ampere inductive at 29 volts d-c or 115 volts a-c

Contact Arrangement:
MHJ-12D: 4 PDT
MHJ-18D: 6 PDT

Temperature:
Minus 65°C to plus 125°C

Vibration:
10–55 cps at 0.125 inch double-amplitude
55–2000 cps at 20g

Operating Shock: 100g

Altitude:
Sea level to 80,000 feet

Weight:
MHJ-12D: 3.0 ounces
MHJ-18D: 4.2 ounces

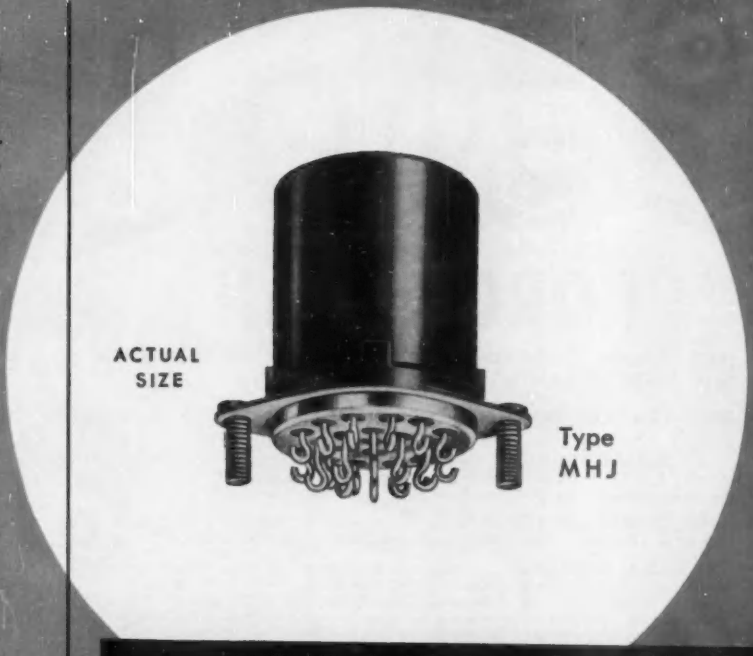
Insulation:
1000 megohms minimum

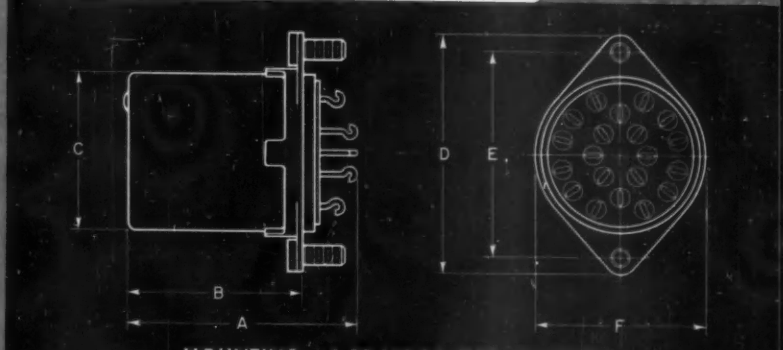
Dielectric Stress:
1000 volts rms at sea level;
450 volts rms at 70,000 feet

Initial Contact Resistance:
.03 ohms maximum at .01 to 2 amps

Operate Time:
15 milliseconds or less at rated voltage at 25°C

Release Time:
5 milliseconds or less at rated voltage at 25°C





MOUNTING = 6-32 NC-2A THD. (2) STUDS

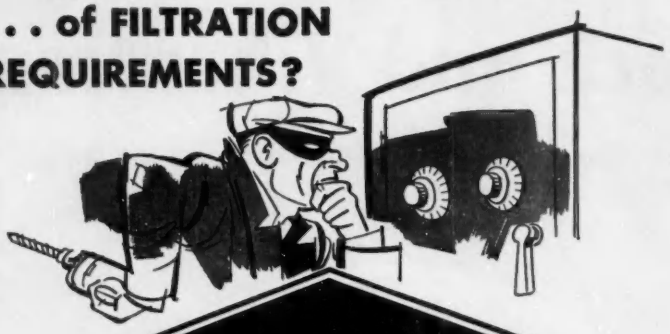
	A	B	C	D	E	F
MHJ-12D (4 Pole)	1¾ max.	1 5/16	1 1/64	1 21/32	1.406	1⅛
MHJ-18D (6 Pole)	1¾ max.	1 5/16	1 3/16	1 13/16	1.562	1 5/16

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Stopped by a TOUGH Combination...

... of FILTRATION REQUIREMENTS?

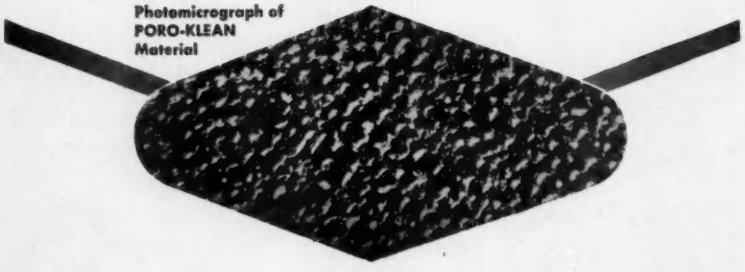


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PORO-KLEAN

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- **HIGH TENSILE STRENGTH** . . . up to 15,000 psi, allows Poro-Klean Filters to withstand differential pressures of more than 3500 psi and to handle extremely viscous liquids at relatively high flow rates.
- **HIGH CORROSION RESISTANCE** . . . allows the filtration of – or cleaning by – substances that would quickly damage other filter materials.
- **NO MEDIA DISCHARGE** . . . Cuno's unique manufacturing and control methods result in a much stronger material with *all* particles securely bonded at several points of contact. Independent tests have *proved* that Poro-Klean produces no product contamination due to media discharge . . . even under conditions of extremely high differential pressures and severe vibration.
- **UNIFORM FINE FILTRATION** . . . with standard material down to 5 microns. Material for sub-micronic filtration available on special order.



Photomicrograph of PORO-KLEAN Material

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EDGE-TYPE, WIRE-WOUND, FIBER CARTRIDGE and POROUS METAL FILTERS

Application Engineers in Principal Cities

WHAT'S NEW

400 Attend Magnetic Amplifier Conference

—PITTSBURGH

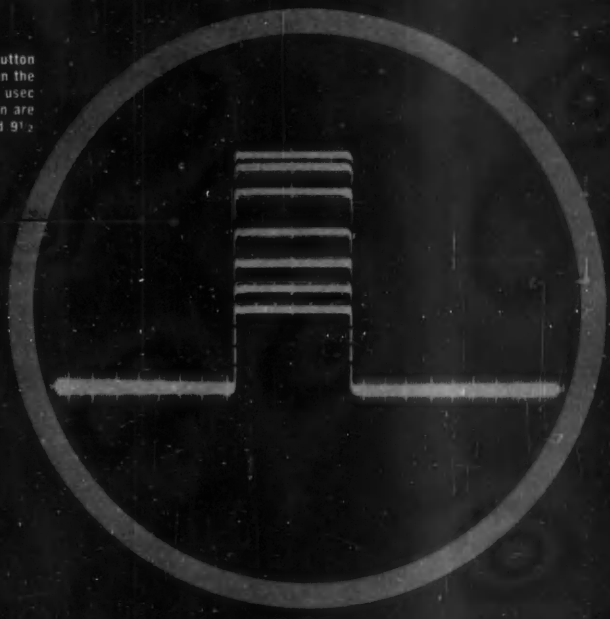
Eighteen technical papers were presented at the Special Technical Conference on Magnetic Amplifiers sponsored by AIEE and IRE Sept. 4-6.

The opening session, covering new circuits and techniques, began with a description of a novel circuit for ac control in which emf's induced in the signal winding are cancelled to give increase in gain. A second paper considered capacitance-tuning of the load to improve the speed of response by eliminating amplifier inductance. This was followed by a review of the operating characteristics of the 50-percent-efficient, push-pull, dc bridge circuit used to supply the armature of the dc shunt motor in an airborne servo-control system. The final paper of the group discussed measurement of the torque output of amplifiers used for driving two-phase servomotors.

In the second session, L. A. Finzi of Carnegie Tech introduced the education problem: how to train young engineers in the field of magnetic amplifiers. A survey of square-loop magnetic materials was then presented, from which it appears that useful new materials are on the way. This was followed by three papers on half-wave fast-response amplifiers covering triggering and reset action.

Considerable interest and discussion was stimulated by a two-part paper by R. M. Hubbard and M. M. Bishop (Boeing Airplane Co.) on magnetic amplifier design, which claimed to be a compromise between strictly empirical methods on one extreme and rigorous mathematical methods on the other. The discussion period brought out some criticisms of the authors' assumptions in arriving at optimum core proportions. Two papers on three-phase amplifier behavior covered the inductive load action of a half-wave circuit and a new technique of transistor control of the flux reset of each reactor of a six-element circuit to establish proper load sharing and balance. The concluding paper in this session was by W. A. Geyger (U.S. Naval Ordnance Laboratory) on a low-level (0 to ±10 millivolt) self-balancing amplifier of the differential feedback type for thermocouple, strain-gage, or resistance-thermometer type applications. (A zero stability of 100 microvolts per 8 hours was obtained at room temperature when the ampli-

Fidelity of 404 push-button attenuation is shown in the multiple exposure of a 1 usec pulse. The db levels shown are ½, 1½, 3½, 5½, 7½ and 9½



0.018 usec
RISE TIME

100,000 pps
REP. RATE

Du Mont

404

Pulse Generator

- Repetition rates up to 100,000 pps, manual trigger for single pulse
- 0.018 usec maximum pulse rise and fall time
- Pulse width continuously adjustable from 0.05 to 100 usec
- 50 volts maximum output into 50 ohm impedance
- 59.5 db of attenuation in 0.5 db steps with no pulse degradation
- Hard tube circuitry eliminates jitter due to hydrogen thyratron erratic firing.



The Du Mont 404 Pulse Generator sets new standards for stability and versatility, outmoding pulse generators employing hydrogen thyratrons. The performance of the 404 reflects the entirely new "hard-tube" circuitry concept employed.

The capabilities of the 404 provide excellent facilities for ultra-high frequency studies at moderate cost. Its hair-line firing of sharp-edged pulses, push-button stepped attenuation, high rep rate, minimum jitter, easy-to-use front panel and control layout, internal delay from 2 usec before trigger to 100 usec after—all add up to a multiple use instrument that's good for years of dependable performance.

Price **$675**

Rack-mounting model $690

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PROBLEM #5

Design an hermetically sealed, miniaturized power supply to provide 6600V, DC, at 100 microamperes load, when connected to a source of 115V, 400 cps. Power supply to operate in an ambient temperature range between minus 55°C and plus 85°C. Minimum life to be 5000 hours at full load. Full load input current must not exceed 0.05A. Output voltage regulation, no load to full load, to be 400 volts DC maximum. Maximum ripple voltage at full load to be 250 volts, peak to peak. Casing to be in accordance with the applicable requirements of MIL-T-27. Power supply to have low external magnetic field. Preferred maximum dimensions to be 3-3/4" x 3-3/4" x 1-3/4" thick.

SOLUTION BY PEERLESS

Power Supply: Hermetically sealed, AC to DC.
Construction: Oil filled metal casing in accordance with applicable requirements of MIL-T-27.
Duty Cycle: Continuous.
Life: Greater than 10,000 hours. (Measured)
Ambient Temperature: Plus 85°C maximum, minus 55°C minimum.
Input: Two terminals, 115V, 380 cps to 420 cps.
Input Current: .045A at full load.
Output: One terminal and case, 6600V DC at 100 microamperes.
Regulation: 350V, no load to full load.
Ripple Voltage: 200V peak to peak.
External Field: Nil.
Dimensions: 1-17/32" x 3-17/32" x 3-19/32" plus 1-1/16" over terminals.

Peerless transformers have long been the first choice of engineers. One important reason for this marked preference is the fact that the Peerless engineering staff is unsurpassed in designing transformers to unusual and difficult specifications. Undeviating dependability is assured by the most rigid quality control and advanced custom production techniques.

Consult Peerless for the best solution to your quality transformer requirements.

PEERLESS **Electrical Products**

A DIVISION OF ALTEC

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WHAT'S NEW

fier was supplied from a ferroresonant constant voltage transformer.)

The final session opened with an invited paper by H. F. Storm reviewing applications of nonlinear magnetic circuits. Other application papers described a magnetic amplifier limit switch, a dc transformer with continuously adjustable ratio from 3:1 to 1:3 for industrial control purposes, and a voltage regulator for a 3-kw dc generator used in computer systems. A 100-watt, 2,400-cycle switching dc to ac converter synchronized to a 400-cycle source represented one of the few mentions of transistors at the conference. This operated as a power supply for magnetic amplifiers, which have temperature stability features and other advantages that the transistor engineer cannot readily achieve.

Proceedings of the conference ($4) will be available from V. J. Louden, General Electric Co., Schenectady, N. Y. Next year's magnetic amplifier meeting will be held on the West Coast and the emphasis will be on nonlinear magnetic techniques in addition to amplifiers. **–A. G. Milnes**

Philadelphia Hosts Nuclear Instrument Symposium

For the seventh straight year, the Philadelphia ISA will sponsor a nuclear instrument symposium along with an Instrument Fair. This year's conclave will be held at the new Philadelphia Sheraton Hotel Nov. 7-8.

Among the papers to be presented:

▶"Primary Elements for Nonnuclear Measurements" by Clyde C. Scott (Minneapolis-Honeywell) will describe new developments in measuring elements which have been adopted for use in nuclear reactor systems outside the reactor; what measurement problems are still unsolved, and possible trends of future instrument design to meet these problems.

▶"Application of Nuclear Energy in Process Instrumentation" by Frank H. Low (Tracerlab, Inc.) will outline types of nuclear radiation equipment available for making process measurements such as level, flow, density.

▶Discussions of reactor controls, including "Typical Applications of Reactor Controls", "Reliability Problems of Reactor Control", and "Overall Instrumentation of a Nuclear Power Plant".

Over 70 manufacturers of instruments plan displays that will cover the whole process control field. Advanced registration for the meeting is $3; registration at the door, $3.50.

TECHNIQUES and DEVELOPMENTS
in oscillographic recording

FROM
SANBORN

CIRCUIT DESIGN AND TYPICAL USES OF THE "150" CARRIER PREAMPLIFIER

One of the most frequently used plug-in front ends for Sanborn 150 Series oscillographic recording systems is the Model 150-1100 Carrier Preamplifier, since with it a "150" system can record such variables as force, temperature, strain, pressure, displacement, velocity, flow, acceleration — or any variable which can be expressed as a suitable input signal by a transducer. The "1100 Carrier" will operate with a variety of different transducers and bridge circuits, which will be mentioned later on.



In the block diagram (Fig. 1),

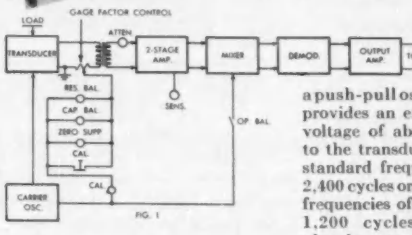


FIG. 1

a push-pull oscillator provides an excitation voltage of about 5 v. to the transducer at a standard frequency of 2,400 cycles or optional frequencies of 600 and 1,200 cycles, using plug-in components. This excitation voltage also feeds the Balancing, Calibration and Zero Suppression circuits. (The Balancing controls allow correction of resistive and reactive signal leakage from the transducer, so that at zero load the net signal to the Preamplifier is zero. The Zero Suppression feature permits bucking out a large static load so that a small part of the load can be expanded over the full recording chart. The Gage Factor control allows the zero suppression range to be made equivalent to some convenient transducer load, or the full load rating of the transducer, and also causes the calibration signal to represent 2% of that load.) Transducer output is fed to the transformer through the Gage Factor potentiometer, across which the Balancing-Calibration-Zero Suppression circuits develop a voltage effectively in series with the transducer output. The mixer receives a suppressed carrier AM signal and re-inserts a carrier component, to make its output a conventional AM signal whose modulation represents the transducer load. The modulation signal (whose amplitude and polarity represent magnitude and direction of transducer output) is recovered by the demodulator and fed to the output amplifier, which in turn excites the Driver Amplifier and recording galvanometer of a "150" system.

Transducers which may be used with the Carrier Preamplifier include strain gage half-bridges or full-bridges, commercial resistance or reactance bridges, differential transformers and resistance thermometer bridges. The transducer chosen should provide at least 18.0 microvolts per volt of excitation at the minimum load to be recorded, for a one cm. deflection; impedance should be 100 to 1000 ohms. With strain gages, normal operation provides sensitivities of 50, 20 or 10 micro-inches per inch for each cm. on the recording, depending on the number of active gages. With resistance thermometers, if 1°C. or 2°F. per cm. stylus deflection is sufficient sensitivity, the user can construct his own resistance thermometer by including a 3 ohm coil of copper wire in one arm of an equal arm 100 ohm bridge.

Helpful information about the use of transducers with the 150-1100 Preamplifier is contained in the following Sanborn RIGHT ANGLE articles (reprints on request): Coupling Differential Transformers, Aug. and Nov. 1956; Filter Networks for use with Force Dynomometers, Nov. 1956; Calibration with 1-, 2- or 4-arm Strain Gage Bridges, Aug. 1955; Theoretical and Actual Applications of Bridge Circuits, May and Aug. 1954.

Wing flutter recording to infrared research . . . with the versatile "1100 Carrier"









Today, Carrier Preamp-equipped Sanborn "150" systems are being used for frequency response tests of process control system components; to record shaft deflections of fluid mixing equipment; in infrared research . . . vehicular traffic studies . . . submarine hull vibration measurements. Applications are limited only by the transducers available.

These are applications of only one "150" front-end; eleven more interchangeable, plug-in Preamplifiers increase the scope of Sanborn oscillographic recording systems to meet an almost infinite variety of research, production and field testing requirements. All Sanborn "150" direct writing systems record inkless traces in true rectangular coordinates; all provide 1% linearity; Basic Assemblies — equipped with your choice of Preamps — are available from one- to eight-channels, packaged in vertical cabinets, portable cases, or specially modified housings.

Technical data and help with your oscillographic recording problem are always available from Sanborn.

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INDUSTRIAL DIVISION
175 Wyman St., Waltham 54, Mass.

Control it with Comvor®

DATA TRANSMISSION TERMINAL



RFL Model 912
Operates over Wire Circuit or Microwave

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VALVES
MOTORS
GENERATORS
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ETC.

The Model 912 Comvor, an audio frequency shift terminal, is used in the transmission of telemeter, telegraph or control signals over either wire line, microwave, or carrier. Up to 60 individual information channels are available in the audio spectrum.

Reliable frequency shift method of keying is used. All essential controls such as transmitter output level and receiver input level are included.

Each terminal contains its own power supply which provides an additional 60 milliamperes at both the transmitter and receiver for the operation of relays, stepping switches, selector magnets, and other components used in telemetering, control and telegraph applications.



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Radio Frequency
LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

AROUND THE BUSINESS LOOP

Quality Goes Before Brand On Servomechanisms' Shelf

Servomechanisms, Inc. had a certain philosophy in mind when it developed a new marketing technique for its Mechatrol Div., whose Components Group specializes in instruments for systems. The philosophy was this: If the finished system is going to amount to anything, the preliminary breadboard must be more than a slapdash arrangement of badly matched components. In fact, it should be pretty close to the shape the system takes just before the sides of the little black box close in around it.

It could almost be said that the quality of the system can be measured by the care with which it is breadboarded, and quality of the breadboard measured by how little component refinement must be done to make it a finished product.

To fully exploit this philosophy, however, it was necessary that Servomechanisms crash the brand barrier and stock components made by other manufacturers besides itself. The reason was academic: the purpose of the new policy is faster delivery to the engineer or designer waiting on the other end of the mail route, but this speed hardly amounts to a thing unless there is an accompanying reduction in trial and error. In other words, if the part isn't satisfactory, it doesn't matter how soon it gets there.

Servomechanisms, says Mechatrol's Advertising Coordinator Elliott Edrick, would be the first to admit that as far as some of its components go, there are companies that make better ones. This is only natural in a period of acute specialization, and the company that doesn't own up to at least a few weaknesses is living in a fool's paradise. But stocking the products of other companies to make sure that every component that the designer puts into his system is of the highest quality, and doing it with both eyes open and trained on the competition, is taking this drive for realistic thinking into unchartered regions. Still, it's exactly what Servomechanisms has done.

Of course, the components that don't carry Servomechanisms' brand name must still reflect its extremely high standards. And while the intention, says Edrick, is to keep prices commensurate with what the customer would pay if he bought his component from the original manufacturer, sometimes this becomes difficult. But the number of times that this can happen will probably be negligible and even when it does happen the speed with which the part is furnished (often slicing as much as 18 weeks off a normal delivery date) will more than make up for the small increase in price.

For a hypothetical system, Servomechanisms supplies, under its own name, all components except synchros, potentiometers, and 60-cycle motors. And because "supply" as defined by this company implies "test", every component, whether made by Servomechanisms or not, gets a thorough-going test for quality and ruggedness in the laboratory of its own Subsystems Group.

The new marketing approach is complete with catalog, the first of several, says Edrick. This one is simply a listing of what's available from stock; still in the works is a manual on application. Included in the present catalog are more than 200 components frequently used in airborne computer and industrial control. They are listed by type, not by manufacturer (in fact, the makers' names do not appear), and are restricted to conventionally engineered designs.

Sales engineers at Westbury, Long Island, where the Mechatrol Div. is located, are on hand to answer questions and help customers select equipment for particular needs. And the catalog itself carries a section on selection which, says Mechatrol's Manager John J. Dempsey, "may be regarded as a 'handbook' approach to control engineering".

Although certain components will cost up to $300, Dempsey doesn't anticipate any special problems in providing guarantees or warranties under the new program.

Belgian Manufacturer to Build U. S. A-Plant Designs

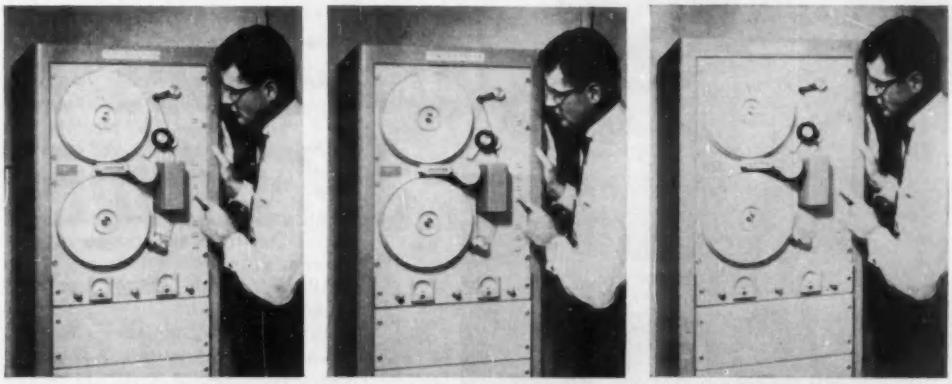
Belgium's largest electrical manufacturer, Ateliers de Constructions Electriques de Charleroi, is the first company to obtain Westinghouse

How the Queen's picture kept its charm

Introducing "FAXTAPE"— facsimile on magnetic tape

We were entirely in accord with the British and Canadian points of view. Her Majesty's visit to Canada deserved special effort...which meant, from us an earlier-than-planned unveiling of magnetic-tape facsimile recording.

To disseminate phone-line news photos of the occasion, Ampex delivered FAXTAPE number one to Canadian Overseas Telecommunication Corporation's Vancouver office. By recording pictures off the wire onto tape, C.O.T.C. was prepared for retransmitting to overseas with no visible loss of quality – desirable for any subject – even more so for the Queen.



FAXTAPE records its own photograph and provides a revealing comparison. Left photo was printed directly off the facsimile wire. Center is the photo after being received on tape and retransmitted. Right is the same photograph after being retransmitted the conventional way off a facsimile print.

A SLOW-SCAN COUSIN OF VIDEOTAPE

Ampex's FAXTAPE is to facsimile as Videotape is to television. It records the electrical signals used in picture transmission. Tape playback reproduces identical voltage patterns, retransmitting the picture and/or feeding a transceiver to make a negative or print.

FAXTAPE is a versatile adaptation of an Ampex FR-1100 instrumentation tape recorder. FM-carrier electronics provide faithful amplitude reproduction for accurate grey-scale with a tape speed of 7½ in/sec. matching phone-line frequency response of 2500 cycles/sec. A real technical achievement in the system is a tough, reliable time standard so precise that the drift is only one second per week. This keeps picture skew down to imperceptible levels.

PICTURE TRICKS AND PRACTICAL ANSWERS

For news photos, weather maps, documents and military data, picture quality no longer demands simultaneous transmission to all receiving points. From tape a second-generation facsimile is as good as the original. Even a third or fourth tape generation is entirely acceptable.

For unattended receiving, FAXTAPE provides one whole hour of recording time per reel. Unlike a facsimile transceiver, magnetic tape does not require makeready on each picture – and incidentally eliminates chance of wrong scanning speed or photo development errors. Voice instructions, coding and scale are recorded on the tape together with the picture itself.

Lines and radio links can be used more effectively and economically with FAXTAPE. Facsimile can be collected on tape and held for available line time or clear broadcast conditions. Also, when wider frequency bands are available, the tape can be speeded up many fold reducing transmission time accordingly.

Tricks? FAXTAPE plays back an electronic picture. You can stretch it, shrink it, speed it up, slow it down, invert the grey scale, juggle the values, or feed it all to a computer – subject only to the limits of human ingenuity. Any ideas?

Can we send you a brochure? answer questions on a specific application? or mail more of this informative ad series direct? For any of these requests, please write Dept. HH-9.

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District offices serving all areas of the United States and Canada; Foreign Representatives in countries around the world.

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ONE OF A SERIES 9



Series FR-100



Series 800 Mobile and Airborne



Model FR-200 Digital

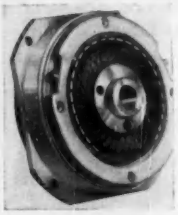


Series FR-700 Logic Recorders

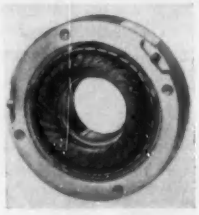


Series FR-1100

AT LAST
a Complete line of
D. C. TORQUE MOTORS
FOR DIRECT DRIVE SERVO APPLICATIONS



IN TYPICAL HOUSING

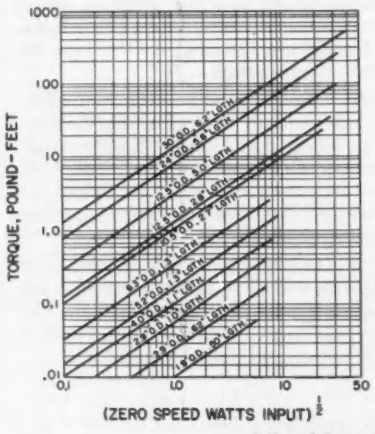


WITHOUT HOUSING

- High angular acceleration by utilizing direct drive (4,000 rad./sec.^{2})
- High peak torque per unit volume
- Minimum control and total power input
- Rapid electrical response
- Optimum shape for compact systems

THIS DESIGN TAKES MAXIMUM ADVANTAGE OF THE PROPERTIES OF DC CONTROL POWER AND PERMANENT MAGNET FIELDS.

TYPICAL RATINGS



Matching Rotary Amplifiers Also Available

For further information and Catalog write to:

INLAND MOTOR CORPORATION
MANUFACTURERS OF ELECTRICAL MACHINERY
23 W. WASHINGTON AVENUE
PEARL RIVER • NEW YORK

WHAT'S NEW

technical information for production of atomic power plants. The agreement signed by the two companies permits the production of licensed equipment in Belgium and its sales outside as well as within the country.

Westinghouse will train engineering and operating personnel as well as provide detailed design and manufacturing information.

Daystrom Plunges Into Missile Systems Work

Daystrom, Inc., which has been supplying components and equipment for a variety of missile projects, has now decided to tackle the development and manufacture of complete systems for missile guidance and control. First step was a reorganization of several Daystrom subsidiaries into an Avionics Group.

Affected by the change are Daystrom Pacific Corp. (gyroscopes, potentiometers, and miniature electronic equipment), Daystrom Transicoil Corp. (servomechanisms), Daystrom Instrument Div. (electronic computers), Aircraft Instruments Div. of Weston Electrical Instrument Corp. (specialized avionic equipment) and special research and development facilities at Poughkeepsie, N. Y.

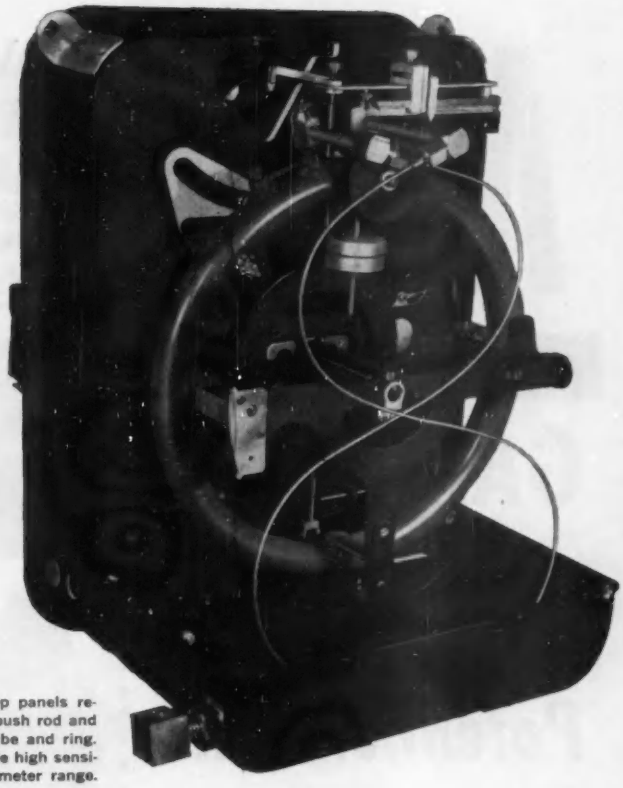
In announcing the move, Daystrom President Thomas Roy Jones seemed unmoved by the clamor currently emanating from other missile suppliers over cutbacks by the Defense Dept. Said Jones, "This step falls in line with the current trend to use contractors who can do a complete job in the military field, whereas, in the past, the government bought instruments and took the responsibility to see that they were properly integrated in the equipment for which they were designed."

Mid-Century R&D Program to Champion the Analog

Financially fatter as a result of negotiations with an investment banking firm, Mid-Century Instrumatic Corp. has called in several top digital computer specialists to head a program designed to "put the analog computer in the running with digital machines for top sales honors in the industrial market". Chief recruit is Mid-Century's new president, Robert K. Stern, formerly vice-president and general manager of Fischer & Porter's Data Reduction & Automation Div.,

HAGAN RING BALANCE FEATURES—NO. 2

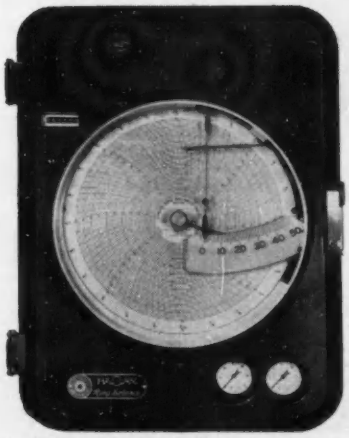
SAFE SENSITIVE METERING at 2500, 6000, 15000 PSIG



Rear of Ring Balance Meter with side and top panels removed to show S-tube arrangement. Note the push rod and resistant spring assembly, visible back of S-tube and ring. This feature of the Ring Balance makes possible high sensitivity at low flows and simple adjustment of meter range.

No question about it. The cylindrical tubing used to form the ring and S-tubes of the Hagan Ring Balance meter is the safe, sure means for containing high pressures. There are no gaskets or stuffing boxes to leak, blow out, bind or otherwise spoil this ideal design.

Pressure impulses are brought from the meter terminals to the ring through solid-wall S-tubes which, because of their special configuration and metal-to-metal fittings, provide safe, completely flexible connections and preserve the inherent high sensitivity of the meter.



New, rigid, weatherproof, die-cast, aluminum case. Four-piece back for complete accessibility.

Check these other Ring Balance features with your local Hagan office

1. High sensitivity at low flows due to unique range calibration system.
2. Ease of calibration under operating static pressures with factory-calibrated check weights. No more four-story water columns and telephones.
3. Sealing fluid density and level not critical. No eye-droppers required.
4. Interchangeable ring assemblies for full scale ranges from 0.5″ w.c. to 560″ w.c. Adjustment on any one ring over a 7:1 differential range.
5. Wide range computation and/or compensation by means of built-in, easily checked mechanisms available on most models.
6. Pneumatic or electric transmission also available.

Bulletin MSP-141 describes these features and the new design of the Hagan Ring Balance meter case. ASK US FOR IT.

HAGAN CHEMICALS & CONTROLS, INC.

HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY, HALL LABORATORIES
IN CANADA: HAGAN CORPORATION (CANADA) LIMITED
OFFICES IN: MONTREAL, TORONTO, VANCOUVER, EDMONTON

NOW!

SAVE WEIGHT, SPACE and COST

in computing and control systems

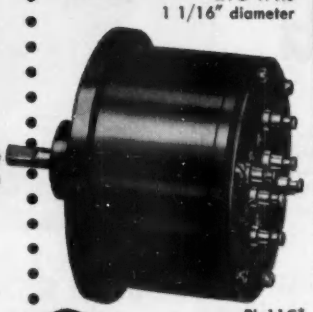
GAMEWELL Sinusoidal Precision Potentiometers

A specially designed oblong resistance element rotating under 4 wipers generates precision sine and cosine voltages, proportional to the sine or cosine of the shaft rotation angle. Functions produced to an inherent accuracy and smoothness unobtainable by other resistive methods. Can replace eccentric gears, cams and complicated mechanisms in computing, analyzing, navigational and control systems.

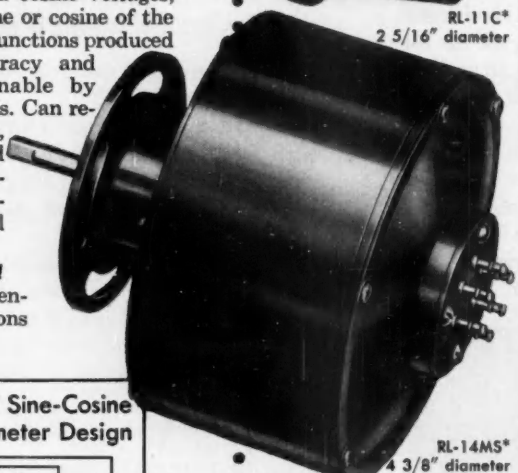
Send for technical data! Functional detail, dimensions and specifications will help you apply.



RVG-17XS
1 1/16" diameter



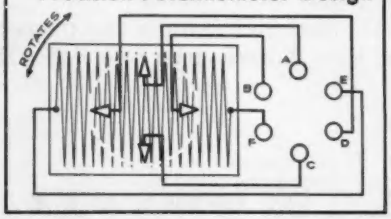
RL-11C*
2 5/16" diameter



RL-14MS*
4 3/8" diameter

*Described in full in Radiation Laboratory Handbook, Vol. 17.

Sketch of Gamewell Sine-Cosine Precision Potentiometer Design



Can be used as a 1 brush device, 2 brush (sine) and 2 brush (cosine) device, or in combinations — to produce various sinusoidal variations. E–F = V_{in}, A–C & B–D = V_o.

THE GAMEWELL COMPANY
Newton Upper Falls 64, Mass.

GAMEWELL®

PRECISION POTENTIOMETER DIVISION

and an old hand at pushing back the computer frontier.

The R&D program, says Stern, "will be directed towards producing and marketing equipment which adds programming techniques previously used only in digital machines. This will further increase the application of our analog computer systems as research and development tools and expand their usefulness to continuous industrial control on the basis of optimizing efficiency."

Specialists under Stern, who has introduced digital data handling systems to the oil, steel, and chemical industries, will be chosen according to the amount of experience they have had with digital and hybrid computing problems. "We also plan the sale of auxiliary equipment which can be used with existing computers for modernizing control and programming," Stern adds, pointing to a sales forecast of $10 million for his company by 1961.

Represented by top executives on Mid-Century's new board of directors are Hallgarten & Co., the investment banking firm with which Mid-Century negotiated; PIC Design Corp.; Neptune Meter Co.; and Federal Machine & Tool Co., Inc.

New Companies in the Field

Hydel, Inc., an independent R&D venture formed by 10 former members of MIT's Dynamic Analysis & Control Laboratory with financial assistance from American Brake Shoe Co., a minority stockholder—in Cambridge, Mass. Brake Shoe has contracted heavily for services of the new company, which will specialize in development and design of control devices, particularly hydraulic servomechanisms, and expects to benefit as much as Hydel itself from the proposed intimate relations.

Says Brake Shoe's Raymond H. Schaefer, vice-president and research director, "This is another step in Brake Shoe's long-range diversification program which calls for, among other things, a leading position in the field of hydraulic and electronic controls." Schaefer will be one of several Brake Shoe executives available to the Hydel staff in a consulting capacity. Another: Alfred H. Munkenbeck Jr., secretary.

President of Hydel is Emery St. George Jr., assistant director of the MIT laboratory since 1952. Active with him on the inside are these seven

(Continued on page 182)

4257

NOW! END READOUT CONFUSION...

with the new KIN TEL digital voltmeter

ANOTHER FIRST FROM KIN TEL! Here is a digital voltmeter that shows numbers on a readable single plane! With KIN TEL's new design, there are no superimposed outlines of numbers in the picture...no confusion caused by dials and old style numerical readouts. This digital readout uses a simple projection system – provides 7,000 to 8,000 hours of lamp life, compared with 100 to 200 hours for ordinary readouts.

FIRST OF A COMPLETE LINE OF DIGITAL INSTRUMENTS! Others include: Converters for measuring AC, ohms, ratios...multiple input scanners . . . serial converters to drive typewriters and punched tape units.

WIDE APPLICATION! KIN TEL digital instruments are ideal for automatic check-out systems for missiles and rockets; computer measurements; process control monitoring; production testing; test system calibration; strain gage, thermocouple and other transducer measurements, and calibration of laboratory and industrial electronic instruments.

Talk to your local KIN TEL representative. Sales and service everywhere. Or write us direct for further information.

See the difference!



ORDINARY READOUT



KIN TEL READOUT



CLEAR AND SHARP, ANY WAY YOU LOOK AT IT

- *100 Microvolt Sensitivity*
- *Automatic, Continuous Standard Cell Calibration*
- *High Reliability*
- *0.0001 to 999.9V–Plus Automatic Decimal and Polarity Indication*

SPECIFICATIONS

Display...Four (4) digit with automatic polarity indication and decimal placement. Total display area 2" high x 7.5" long, internally illuminated. Individual digits 1.25" high.

Automatic Ranges...0.0001 to 999.9 volts covered in four ranges.

Accuracy...0.01% or 1 digit, whichever is larger.

Counting Rate...30 counts per second, providing average balance (reading) time of 1 second, maximum balance time of less than 2 seconds.

Reference Voltage...Chopper-stabilized supply, referenced to an unsaturated mercury-cadmium standard cell.

Input Impedance...10 megohms, all ranges.

Output...Visual display, plus print control. Automatic print impulse when meter assumes balance. No accessories required to drive parallel input printers.

Input...115 volt, 60 cycle, single phase, approximately 75VA.

Dimensions...Control unit, 5¼" high x 19" wide x 16" deep. Readout display, 3½" high x 19" wide x 9" deep.

Weight...Approximately 40 lb.

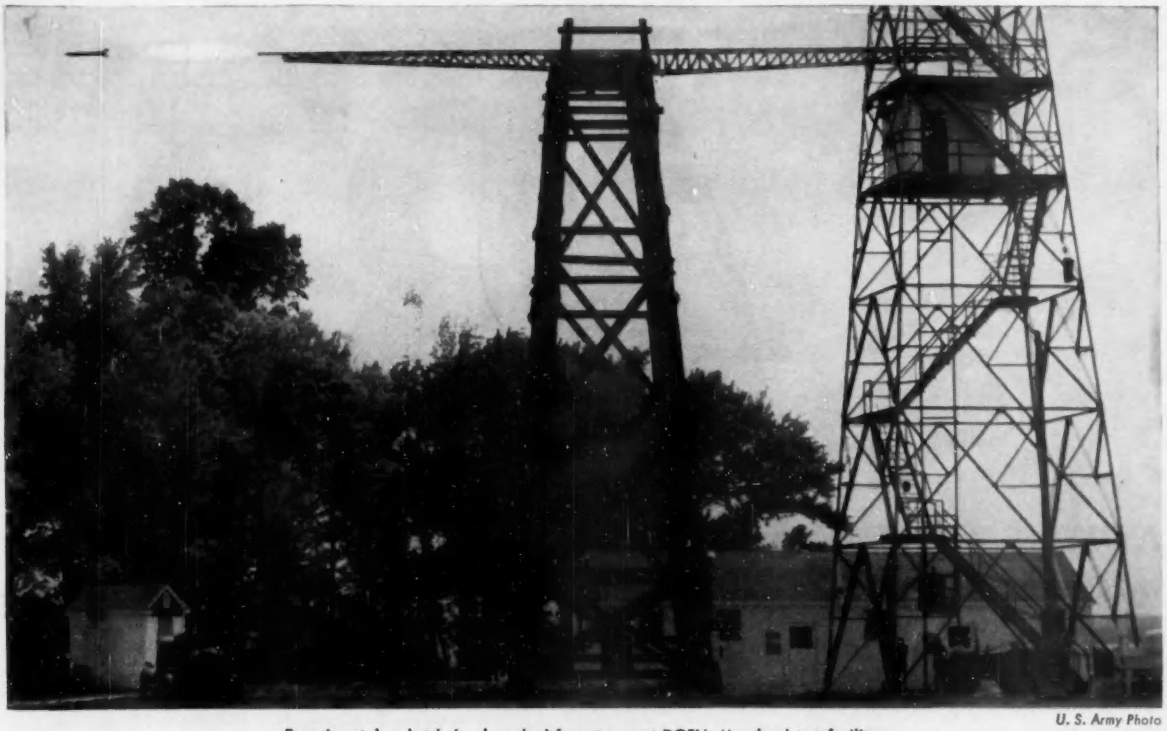
Price...$2,100

Over 10,000 KIN TEL instruments in use today!

KIN TEL

5725 Kearny Villa Road
San Diego 11, California

(KAY LAB)



U. S. Army Photo

Experimental rocket being launched from tower at DOFL's Maryland test facility.

ELECTRONIC AMMUNITION THAT "THINKS" IS DEVELOPED AT ARMY'S DIAMOND ORDNANCE FUZE LABORATORIES

Since 1940, scientists and engineers at Diamond Ordnance Fuze Laboratories, with their industrial contractor counterparts, have made important contributions to electronic ordnance. These include the proximity fuze, greatly improved fuzes for antitank and other special ammunition, and, more recently, fuzing systems for guided missiles. Other basic results of DOFL's research and development teams are new electronic systems which increase the accuracy of measurement of distance, velocity and direction, new electronic and mechanical control systems, and new and radical components and materials. DOFL's main laboratory is in Washington, D. C., and it maintains an extensive test facility at Blossom Point, Maryland. Over 1400 scientists, engineers, technicians, and supporting personnel work in these centers.

Electronic ordnance was born in World War II. Ammunition of this type, a DOFL specialty, senses the presence, distance, and direction of a target and causes the warhead to function at the instant when it will inflict the most damage. Electronic control can be compared to having a sharpshooter in every piece of ammunition. The accurate effect is devastating.

Many advances in ruggedness and miniaturization, pioneered by DOFL, are contributing significantly to peacetime technology. Typical industrial products which sprang from ordnance programs are printed electronic circuits, tough and tiny electronic tubes, and rigid mounting of components in solid plastic blocks. These valuable by-products have contributed heavily to the ability of DOFL's industrial teammates to design safer, smaller, and better components.

This is one of a series of ads on the technical activities of the Department of Defense.

FORD INSTRUMENT CO.

DIVISION OF SPERRY RAND CORPORATION

31-10 Thomson Avenue, Long Island City 1, New York

Beverly Hills, Cal. • Dayton, Ohio



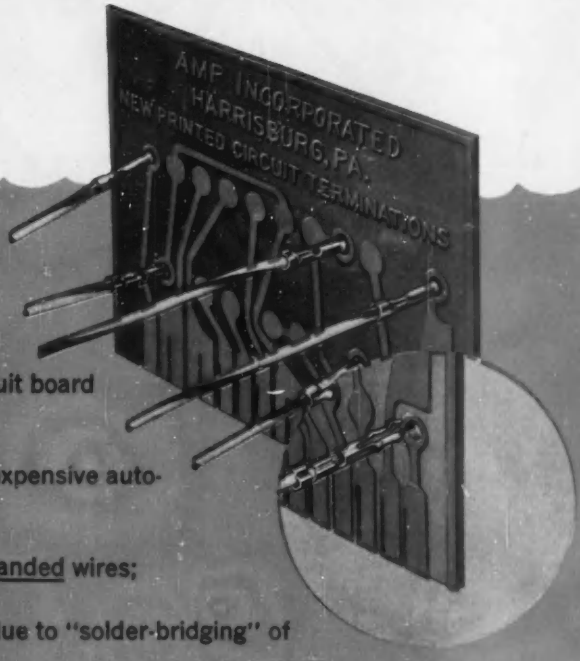
Class of technicians at Ford Instrument is instructed on techniques to be employed in assembling equipment for Army Ordnance project.

ENGINEERS of unusual abilities can find a future at **FORD INSTRUMENT CO.** Write for information.

WELL I'LL BE DIPPED...better

...because the NEW AMP SNAPIN





- Gets leads to the printed circuit board in one assembly operation;
- Eliminates an investment in expensive automation equipment;
- Can be applied to solid or stranded wires;
- Eliminates danger of shorts due to "solder-bridging" of insecure leads;
- Has construction details that promote good capillary flow of solder during the dipping process;
- Is self-retaining, with no damage to the printed circuit board during pre-assembly operations;
- Is self-aligning—no further positioning or deformation is required.

Write today for additional information on the NEW A-MP SNAPIN, *the* AMP-EDGE *Connector and other A-MP products designed for printed circuit applications.*

AMP INCORPORATED

GENERAL OFFICE:

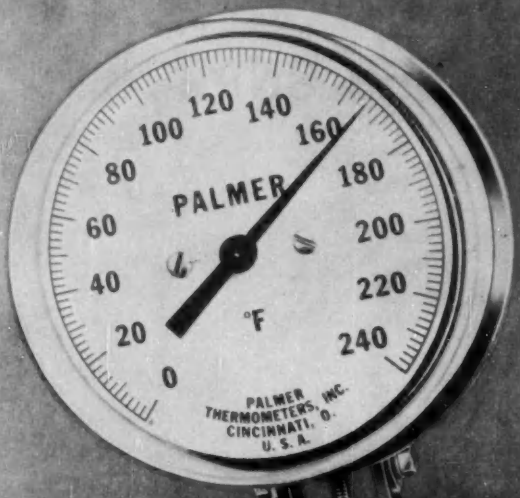
3212 Eisenhower Boulevard, Harrisburg, Pennsylvania

AMP

Wholly Owned Subsidiaries: Aircraft-Marine Products of Canada Ltd., Toronto, Canada • Aircraft-Marine Products (Great Britain) Ltd., London, England • Societe AMP de France, Le Pre St. Gervais, Seine, France • AMP—Holland N.V. 's-Hertogenbosch, Holland

Distributor in Japan: Oriental Terminal Products Co., Ltd., Tokyo, Japan

Outstanding Accuracy



PALMER

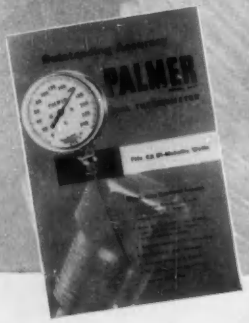
MODEL 1035

DIAL THERMOMETER

Fits All Bi-Metallic Wells

Check these functional features

- Direct-drive Bourdon Coil with a filled system for longer lasting accuracy.
- Stem can be placed at any desired angle and case can be rotated to most readable position.
- External calibration for zero setting.
- Unaffected by stem alignment.
- Accurate to one scale division.
- No sticking at any temperature.
- Non-corrosive case.



Write for Free Bulletin 1035 for complete description and prices.

PALMER THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2515 Norwood Ave., Cincinnati 12, O.

See how the facts speak for themselves

hcd* RADIO RECEPTOR

Petti-Sel SELENIUM RECTIFIERS

are revolutionizing the field!

* high current density



Standard rectifier

RRco. Petti-Sel rectifier

Both rectifiers are rated at 26V, 6 amps, but notice the significant space saving in the compact Petti-Sel unit.

- 100,000 hours estimated life
- Lower voltage drop
- Higher current density
- Less reverse leakage
- Smaller size

compare the size...

compare the specs...

STANDARD SELENIUM RECTIFIERS								
NOMINAL CELL SIZE (INCHES)		RRco. CELL CODE	Continuous DC Amperes at 35° C Ambient					
			SINGLE PHASE			THREE PHASE		
Vert.	Horiz.		Half Wave	Center Tap	Bridge	Half Wave	Center Tap	Bridge
1.0	1.0	M	.11	.22	.22	.29	.40	.33
1 3/16	1 3/16	P	.23	.45	.45	.60	.81	.67
1.5	1.5	Q	.45	.90	.90	1.2	1.6	1.3
2	2	S	.70	1.4	1.4	1.8	2.5	2.1
3	3	U	1.6	3.2	3.2	4.2	5.8	4.8
3 3/8	3 3/8	V	2.0	4.0	4.0	5.3	7.2	6.0
4	4	W	3.0	6.0	6.0	8.0	10.8	9.0
4.5	5	G	3.75	7.5	7.5	10.0	13.5	11.2
4 1/4	6	T	4.2	8.5	8.5	11.0	15.0	12.5
5	6	H	5.0	10.0	10.0	13.3	18.0	15.0
6	7 1/4	L	7.5	15.0	15.0	20.0	27.0	22.5

RRco. PETTI-SEL SELENIUM RECTIFIERS								
NOMINAL CELL SIZE (INCHES)		RRco. CELL CODE	Continuous DC Amperes at 35° C Ambient					
			SINGLE PHASE			THREE PHASE		
Vert.	Horiz.		Half Wave	Center Tap	Bridge	Half Wave	Center Tap	Bridge
1.0	1.0	6	0.2	0.4	0.4	0.6	1.0	0.6
1.3	1.3	11	0.5	1.0	1.0	1.5	2.5	1.5
1.6	1.6	16	0.75	1.5	1.5	2.25	3.75	2.25
2	2	25	1.25	2.5	2.5	3.75	6.25	3.75
2.6	2.6	44	2.25	4.5	4.5	6.75	11.25	6.75
4	4	100	4	8	8	12	20	12
4	8	200	8	16	16	24	40	24
4	12	300	12	24	24	36	60	36
8	8	402	16	32	32	48	80	48
8	12	600	22.5	45.0	45.0	67.5	112.5	67.5
8	16	800	30.0	60.0	60.0	90	150	90

In case you haven't noticed, the yellow and gray areas denote actual comparative sizes of the two rectifier types.

and compare the prices! HCD Petti-Sel rectifiers, developed in Western Germany by Siemens and now made in the U.S. by Radio Receptor, offer many important electrical advantages over standard types plus economic advantages.

See for yourself – We'll be glad to send you further information on this remarkable new rectifier line. Submit your requirements to Section C-11R.

Radio and Electronic Products Since 1922

Semiconductor Division

RADIO RECEPTOR COMPANY, INC.

Subsidiary of General Instrument Corporation

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Radio Receptor products for Industry and Government:
Germanium and Silicon Diodes, Selenium Rectifiers, Thermatron Dielectric Heating Generators and Presses, Communications, Radar and Navigation Equipment

Decco OIL-IMMERSED SOLENOIDS

give incredible performance



INSTALL THEM AND FORGET THEM. TESTS SHOW NO APPRECIABLE WEAR AFTER MILLIONS OF STROKES.

Here's why:

SEALED IN OIL. Each unit is sealed in its own, contamination proof, oil filled, die-cast housing. A convenient, plug-in base allows split-second replacement in case of change in power requirements. Heat dissipation and wear control reach a new level of efficiency in these units.

SHOCK MOUNTED. Only DECCO can give you service-proved, two direction shock-mounting—a valuable bonus in the service-life of your solenoids.

BETTER ENGINEERING. Minimum power loss. 30° to 50° cooler operation. Tremendously greater service-life.

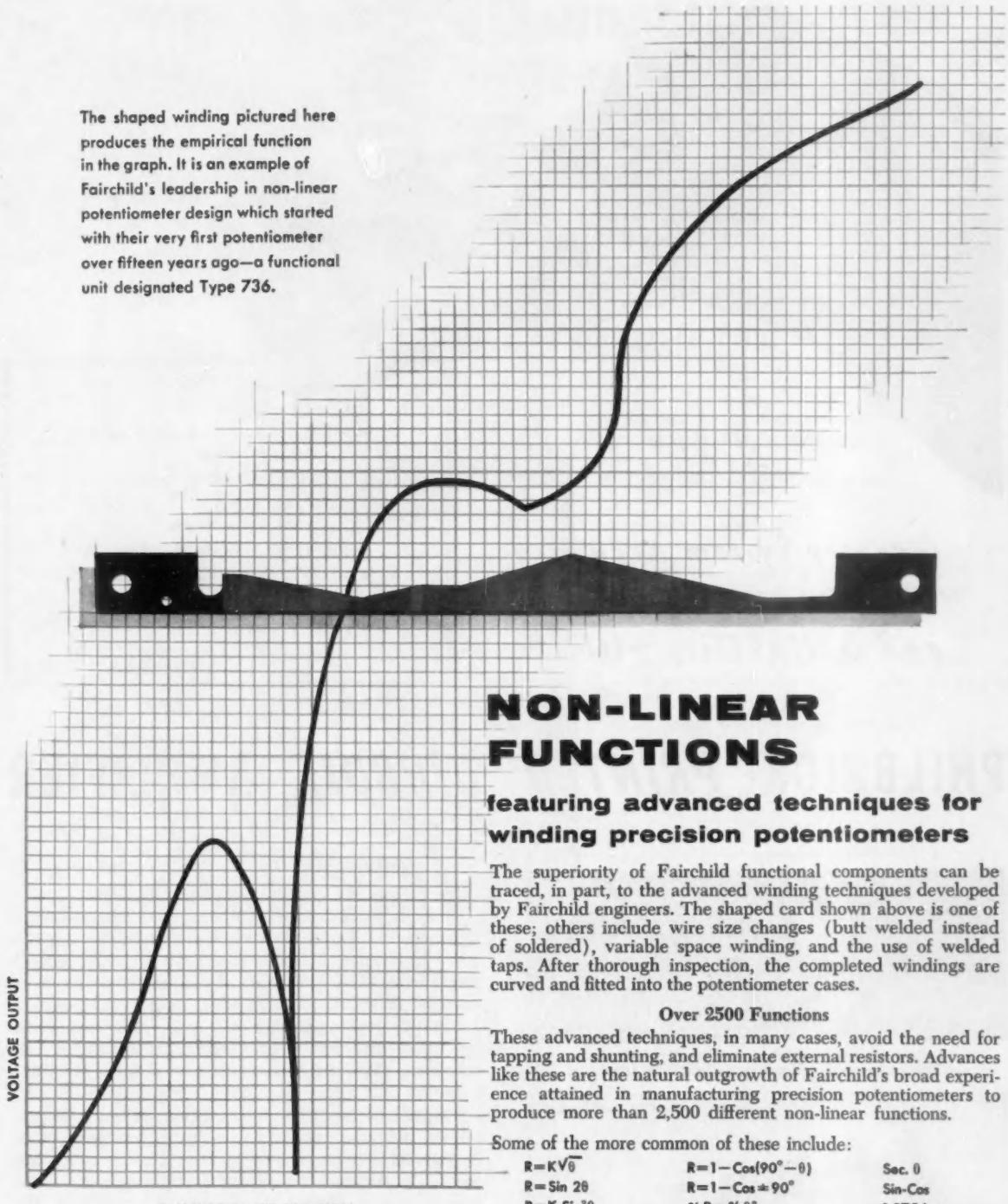
DECCO Solenoids are made in a complete range of types, sizes and mountings. AC or DC. SPECIAL SOLENOIDS will be engineered on request.

Decco SOLENOIDS THE HEART OF DEPENDABLE AUTOMATION EQUIPMENT

DETROIT COIL COMPANY

2435 HILTON ROAD, FERNDALE 20, MICHIGAN

The shaped winding pictured here produces the empirical function in the graph. It is an example of Fairchild's leadership in non-linear potentiometer design which started with their very first potentiometer over fifteen years ago—a functional unit designated Type 736.



NON-LINEAR FUNCTIONS

featuring advanced techniques for winding precision potentiometers

The superiority of Fairchild functional components can be traced, in part, to the advanced winding techniques developed by Fairchild engineers. The shaped card shown above is one of these; others include wire size changes (butt welded instead of soldered), variable space winding, and the use of welded taps. After thorough inspection, the completed windings are curved and fitted into the potentiometer cases.

Over 2500 Functions

These advanced techniques, in many cases, avoid the need for tapping and shunting, and eliminate external resistors. Advances like these are the natural outgrowth of Fairchild's broad experience attained in manufacturing precision potentiometers to produce more than 2,500 different non-linear functions.

Some of the more common of these include:

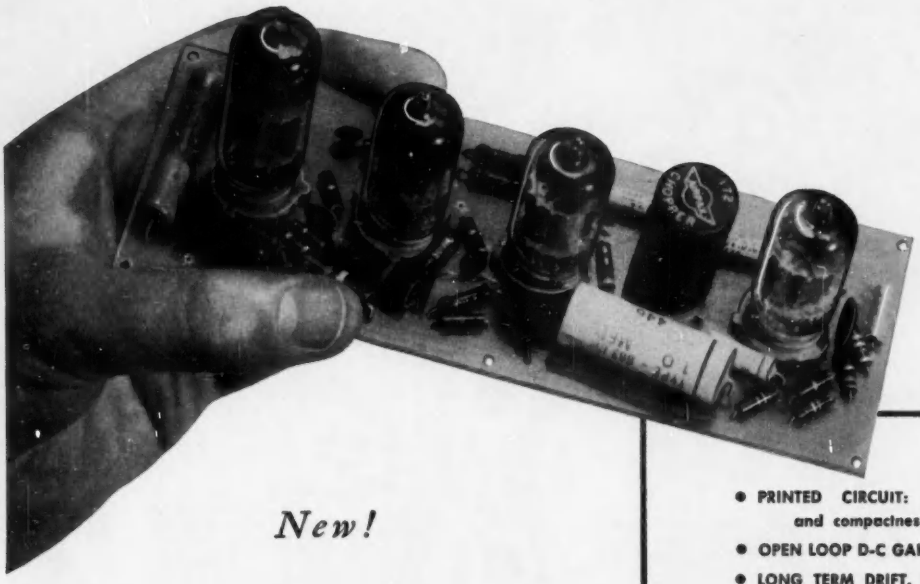
$R=K\sqrt{\theta}$	$R=1-\cos(90°-\theta)$	Sec. θ
$R=\sin 2\theta$	$R=1-\cos\div 90°$	Sin-Cos
$R=K\frac{\sin^2\theta}{2}$	$\%R=\%\theta^2$	1.875 log 2 cycle log

These functions can be provided in many standard types ranging from ⅞" to 3", as well as an infinite variety of specials. Call on this vast experience the next time you have a problem involving non-linear functions—or *any* precision potentiometer problem. Write to Dept. 140-89C, Fairchild Controls Corporation, Components Division:

EAST COAST
225 Park Avenue
Hicksville, L. I., N. Y.

WEST COAST
6111 E. Washington Blvd.
Los Angeles, Calif.

FAIRCHILD
PRECISION POTENTIOMETERS and COMPONENTS



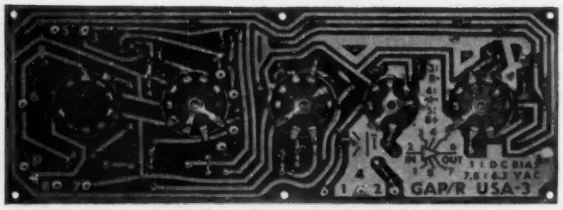
New!

Greater System Accuracy

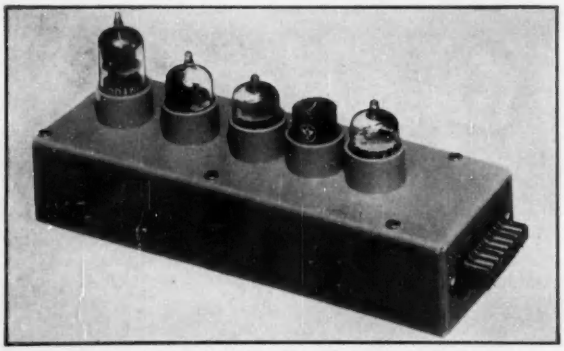
and Reliability with the

- **PRINTED CIRCUIT:** Economy, reliability and compactness.
- **OPEN LOOP D-C GAIN:** 10 million.
- **LONG TERM DRIFT, NOISE and OFFSET:** under 100 microvolts.
- **OUTPUT VOLTAGE RANGE:** ±115 volts.
- **SIZE:** 7" x 2½" board.
- **MOUNTING:** Any convenient method.
- **PRICE:** $95.00.

PHILBRICK *PRINTED CIRCUIT* AMPLIFIER



Underside of Model USA-3 showing printed circuit, amplifier connection scheme, and connecting terminals.



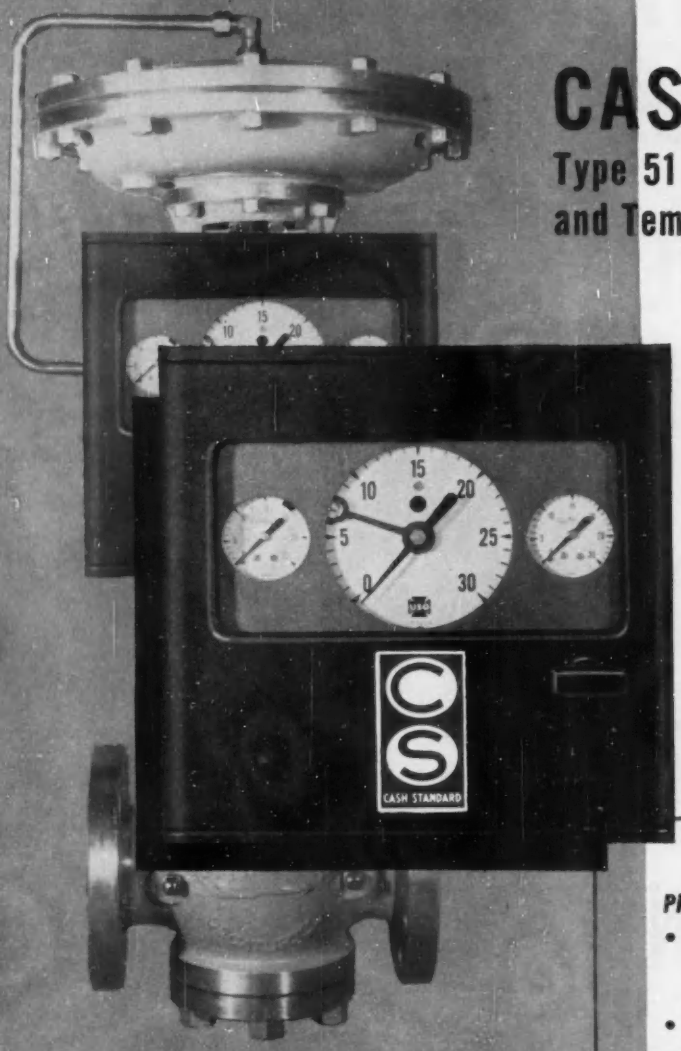
Model USA-3 showing one of the several types of modular packaging available at extra cost.

Model USA-3

High performance combined with the reliability and compactness of a printed circuit design are featured in the new Philbrick Universal Stabilized Amplifier, Model USA-3. It is ideally suited for applications to instrumentation, control and analog computation. Extremely high open-loop d-c gain, wide bandwidth, low noise and wide output range are important performance characteristics of this new chopper stabilized amplifier. An interesting design feature makes this instrument safe against self-destruction, even under prolonged overload conditions or direct grounding of its output. At a price of only $95.00, it offers more performance per dollar than any other amplifier on the market today. *Write to George A. Philbrick Researches, Inc., Dpt. 10-N, for Bulletin USA-3.*

GEORGE A.
PHILBRICK
RESEARCHES, INC.
230 Congress Street, Boston 10, Massachusetts

PROVIDES PRECISE, DEPENDABLE CONTROL OF PRESSURE AND TEMPERATURE...



Cash Standard Type 51 Pilot can be ordered separately or mounted on a Cash Standard Control Valve (Illustration is one example).

CASH STANDARD

Type 51 Pressure Pilot and Temperature Pilot

- Process pressure or temperature gauge incorporated in the pilot
- Calibrated set point adjustment
- Unit construction
- Feedback proportional control—1 to 100% proportional band and differential gap
- Available with proportional, plus automatic reset action
- All-metal, frictionless power relay
- Sapphire nozzle feed orifice with push button cleaner

A WIDE SELECTION OF PRESSURE AND TEMPERATURE RANGES

- Pressure-sensing elements available in phospor bronze, beryllium copper or stainless steel

  Pressure ranges: 0-15 to 0-10,000 psi also 0-30" H_2O and 0-30" Hg vacuum
- Mercury-actuated armored capillary temperature-sensing element available with plain bulb, union connection or union connection with separable socket.

  Temperature ranges available from—40°F. to 1000°F.

WRITE TODAY for Bulletin 978-F containing complete information.

CASH STANDARD

A. W. CASH COMPANY, P. O. Box 551, Decatur, Illinois

Pressure, Hydraulic, Temperature, Process and Combustion Controls

Taylor GRAPHIC PANEL CONTROLS CONSOLIDATED'S NEW, HIGH SPEED PAPER MACHINE

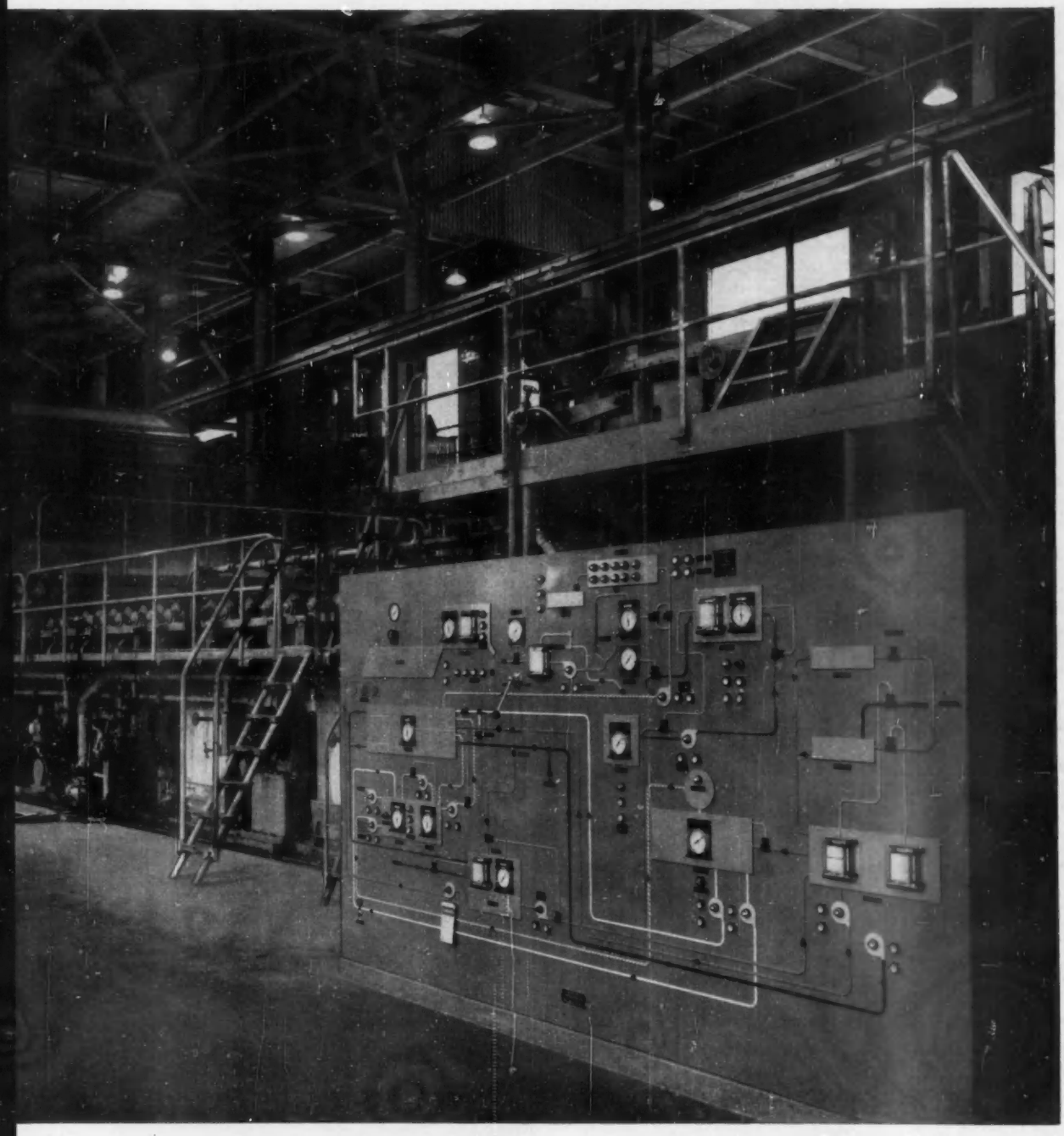


THE new high-speed enamel paper machine at the Biron Division of Consolidated Water Power & Paper Company is capable of producing a sheet of paper 185 inches wide at speeds up to 2000 feet per minute. An automatic graphic panel, made by Taylor Instrument Companies, contributes in a large part to the successful operation of this machine.

The operator's wet end panel, shown above, controls the various water and stock systems

Taylor Instruments
MEAN
ACCURACY FIRST

VISION · INGENUITY · DEPENDABILITY



for the No. 5 machine. The variables are measured, recorded or indicated, and then remotely controlled by the instruments on the graphic panel. Some of the variables are water temperature, water level, stock level, consistency and pH. This panel also controls the stopping and starting of pumps, agitators and other electrically operated devices associated with these systems. Other Taylor instrumentation is employed in the stock preparation system.

The Taylor Instrument Companies is fully equipped to handle instrumentation for complete mills as well as individual projects . . . either in pulping or paper making.

* * *

For more information about how Taylor can help you in your operation, see your Taylor Field Engineer, or write the Taylor Instrument Companies, Rochester, N. Y., or Toronto, Canada.

MINNIE

MINIATURE CONNECTORS

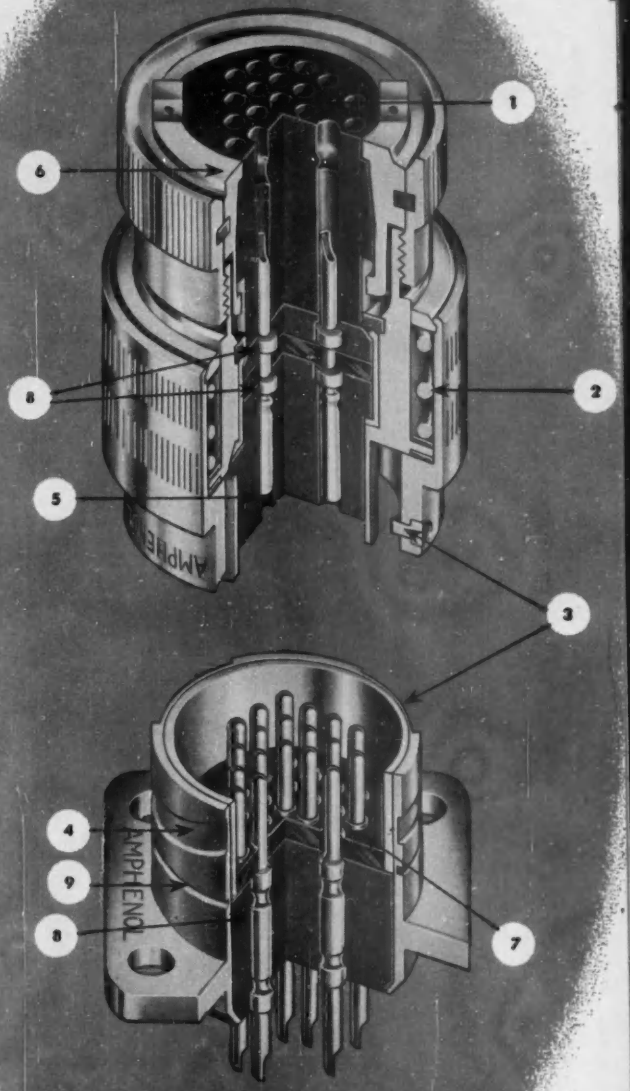
. . . the only miniature connector line fully conforming to the "E" REQUIREMENTS OF MIL-C-5015C.

Meet minniE—a complete line of miniature connectors with outstanding reliability features! The first miniatures to meet fully the "E" performance requirements of MIL-C-5015C, minniE's are environmentally sealed to resist moisture and humidity; ruggedly built to resist shock and vibration; imaginatively designed to provide application versatility.

FEATURES

1. **Environmentally sealed with unitized back end grommet. (Also available with provision for potting.) Either grommet seal or potted seal meets moisture resistance requirement of MIL-C-5015C, Paragraph 4.5.21.**
2. **Spring-loaded coupling ring provides a positive locking action in the bayonet slot, and a constant compensating force which eliminates the effects of resilient face seal compression set.**
3. **Stainless steel bayonet slots and pins reduce wear and frictional characteristics. The three pin bayonet coupling minimizes the rocking action of the mated plug and receptacle.**
4. **Flattened incline angle of bayonet slots reduces mating force requirement.**
5. **Hooded contacts resist test prod damage as defined in Paragraph 4.5.14 of Amphenol Specification 340-43-2108.**
6. **Unitized grommet seal; clamp and grommet form a single unit for ease of assembly and maintenance.**
7. **Face seal gasket with individual barriers to isolate each contact.**
8. **Hard insert dielectric (plus resilient face seal) positively retains contacts with no possibility of contacts being pushed out of the insert.**
9. **A visual full engagement indicator is included in the design to insure the user that he has fully engaged the connectors. The indicator is an orange line around the receptacle shell.**

- **When using mated sealed connectors, no derating for altitude is necessary at 70,000 feet.**
- **Test voltage 1,500 volts RMS 70,000 feet on sealed connectors.**
- **Vibration per Method 204 of MIL-Std-202A. 10 to 2,000 cps at 20 g's.**
- **Temperature cycling range per MIL-C-5015C, Paragraph 4.5.3 increased to 257°F. maximum and —67°F. minimum.**



send COUPON for Complete Catalog

AMPHENOL ELECTRONICS CORPORATION *1830 S. 54th Ave., Chicago 50, Illinois*

Please send me a copy of ***MINNIE*** *catalog.*

NAME_____

TITLE_____

COMPANY_____

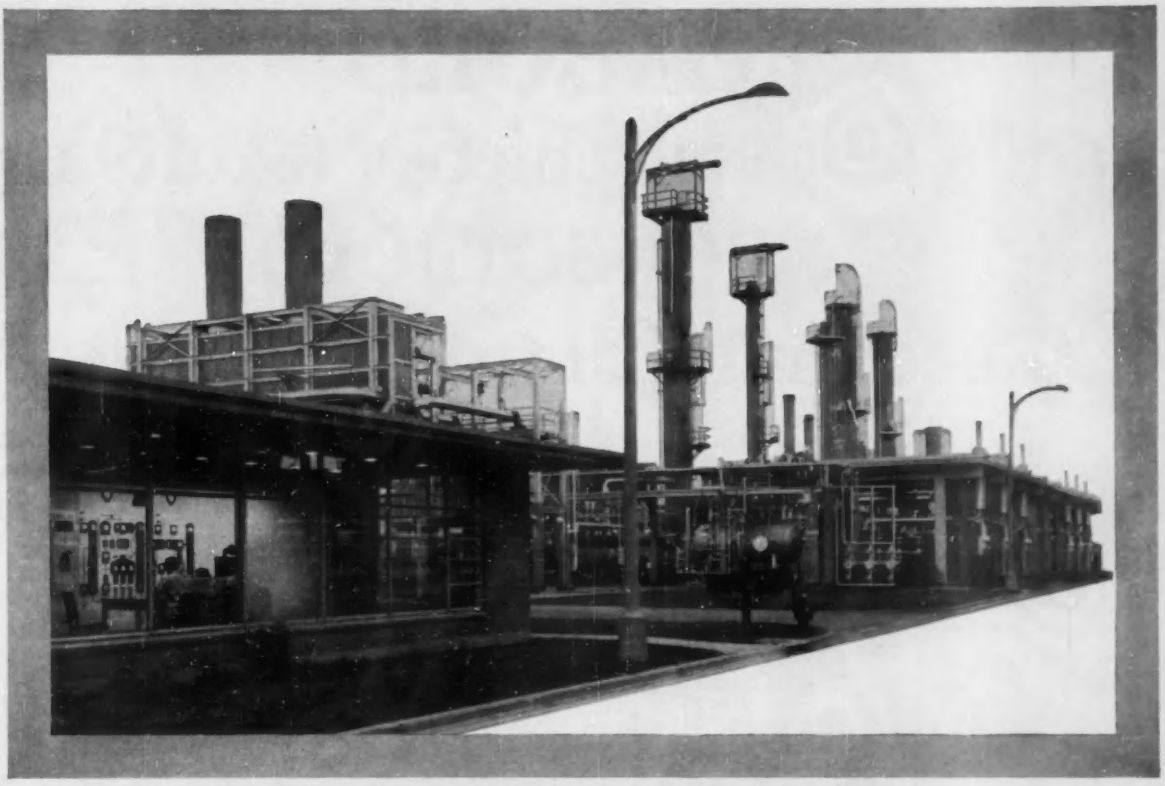
NUMBER & STREET_____

CITY, ZONE & STATE_____

AMPHENOL

AVAILABILITY:

4 CONSTRUCTIONS: "E", Potting, Jacketed Cable, Cable Clamp
5 SHELL SIZES: 12, 14, 18, 20, 22
17 INSERT ARRANGEMENTS: Up to 48 contacts; coax and hermetic seals also



Electronic Control SAVES THOUSANDS OF DOLLARS even before start-up

Here is how: The installation of 'American-Microsen' Electronic Controls eliminated the need for a new control house when a new platformer unit was erected at the Pontiac Refining Corporation in Corpus Christi, Texas.

The existing control house (shown above) is far from the site of the new unit. Transmission distances up to 800 feet were involved—distances too great for conventional process instrumentation. But 'American-Microsen' Electronic Instruments are completely unaffected by distances up to 30 miles. Accurate dc signals are transmitted over simple 2-wire circuits with split-second speed. Consequently, Pontiac found it both practicable and economical to install the new platformer instrument panel right in the existing control house.

In addition, transistors, printed circuits and miniaturized components provide the ultimate in reliability, service life and space-saving simplicity. These are but a few of many reasons why 'American-Microsen' – the all-electronic system that uses only three units – is widely preferred for measurement, transmission and control. Write for literature and ask that a sales engineer from our nearby district office call and explain fully. No obligation, of course.

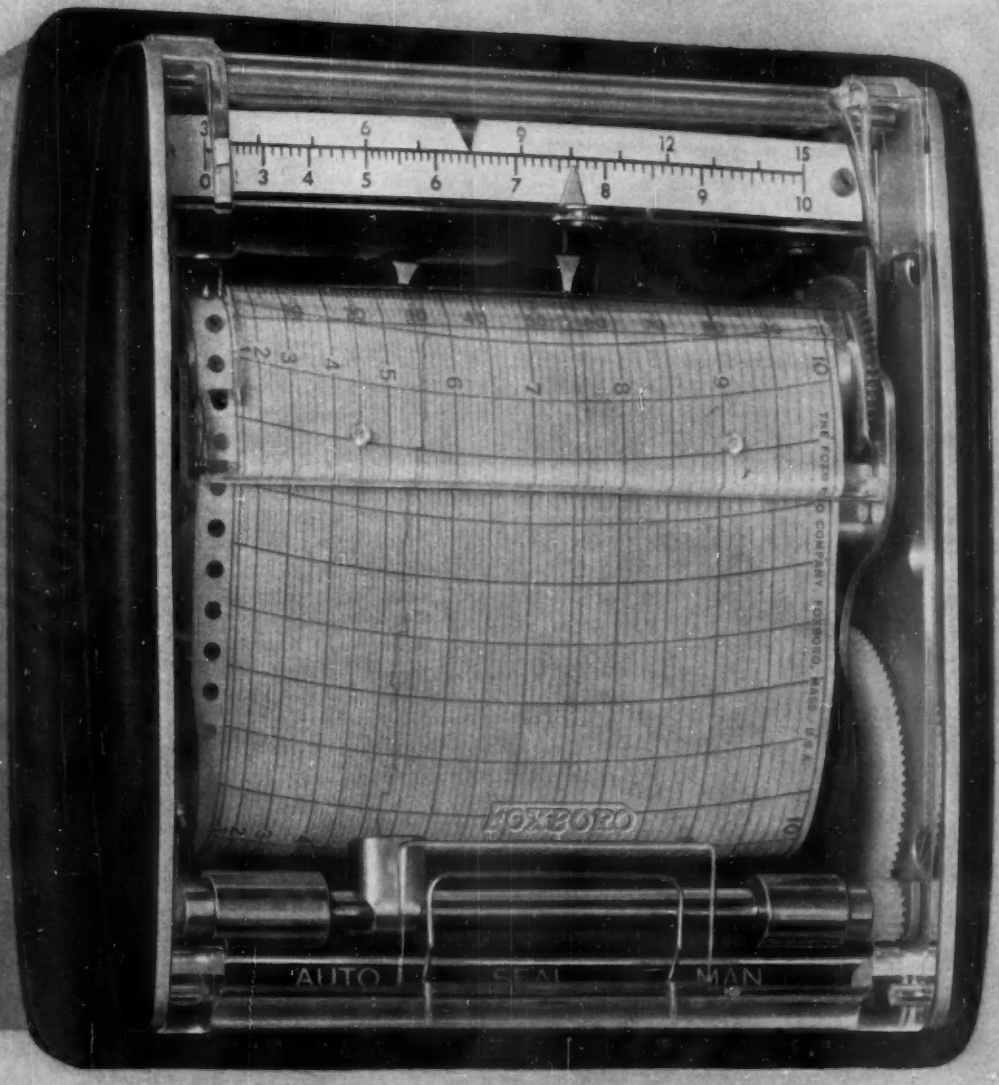
MANNING, MAXWELL & MOORE, INC.

MANNING MAXWELL & MOORE INC. TRADE MARK

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC INSTRUMENTS FOR MEASUREMENT, TRANSMISSION AND CONTROL

FOXBORO
adds new convenience features to CONSOTROL* Recording Control Stations



Shown actual size

*Reg. U. S. Pat. Off.

– further "operating ease" combined with accuracy – readability – top performance

3-pen recording, angle mounting, indicating tear-off bar . . . just a few of the new convenience features you'll find in Foxboro Consotrol Recorders and Recording Control Stations.

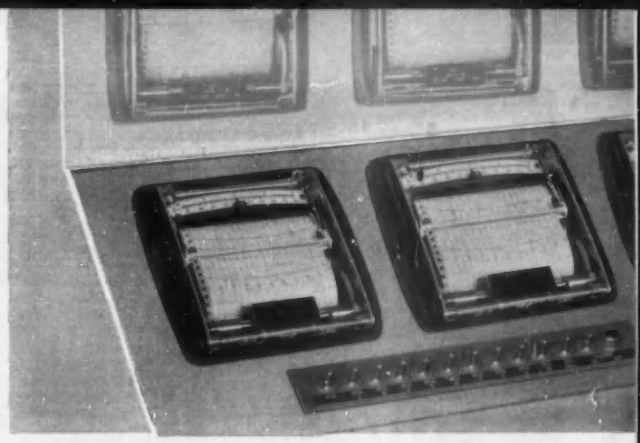
But these new operating benefits are only part of the story. Additional control functions are handled easily with Consotrol Instruments. Auto-Selector control — the control of related variables through a common valve is now possible with Consotrol small-case panel instrumentation, as is centralized control of batch processes.

With their new, exclusive operating conveniences and process control functions, Foxboro Consotrol Recording Control Stations, now, more than ever, provide you with superior centralized recording and control. You'll find they maintain the highest standards of precision and dependability — are the simplest to maintain.

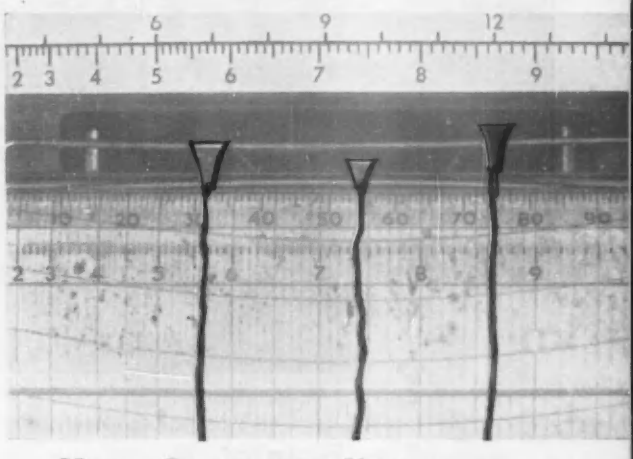
Write Foxboro for full details. Ask for Bulletin 13-18A. **The Foxboro Company, 3611 Norfolk St., Foxboro, Mass., U.S.A.**

FOXBORO

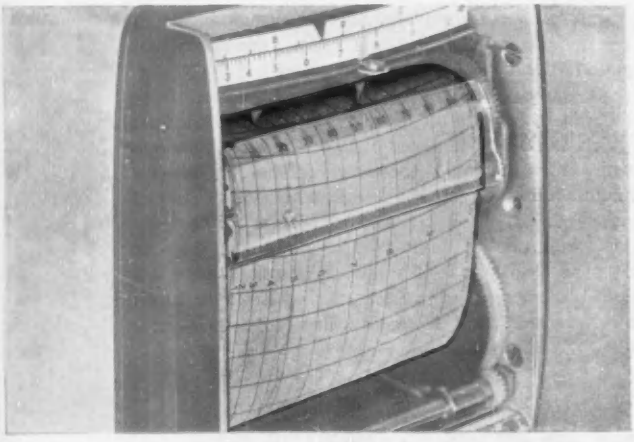
REG. U.S. PAT. OFF.



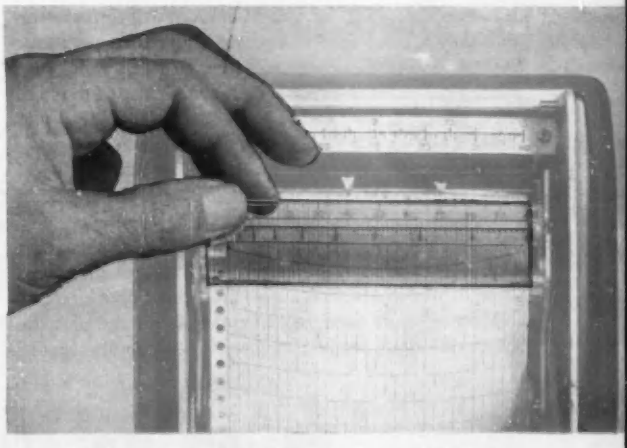
New – angle mounting Now you can panel-mount your Consotrol Recording Control Stations as much as 75° from the vertical, giving you more usable panel space closer to the floor. Operator can read lower instruments without stooping.



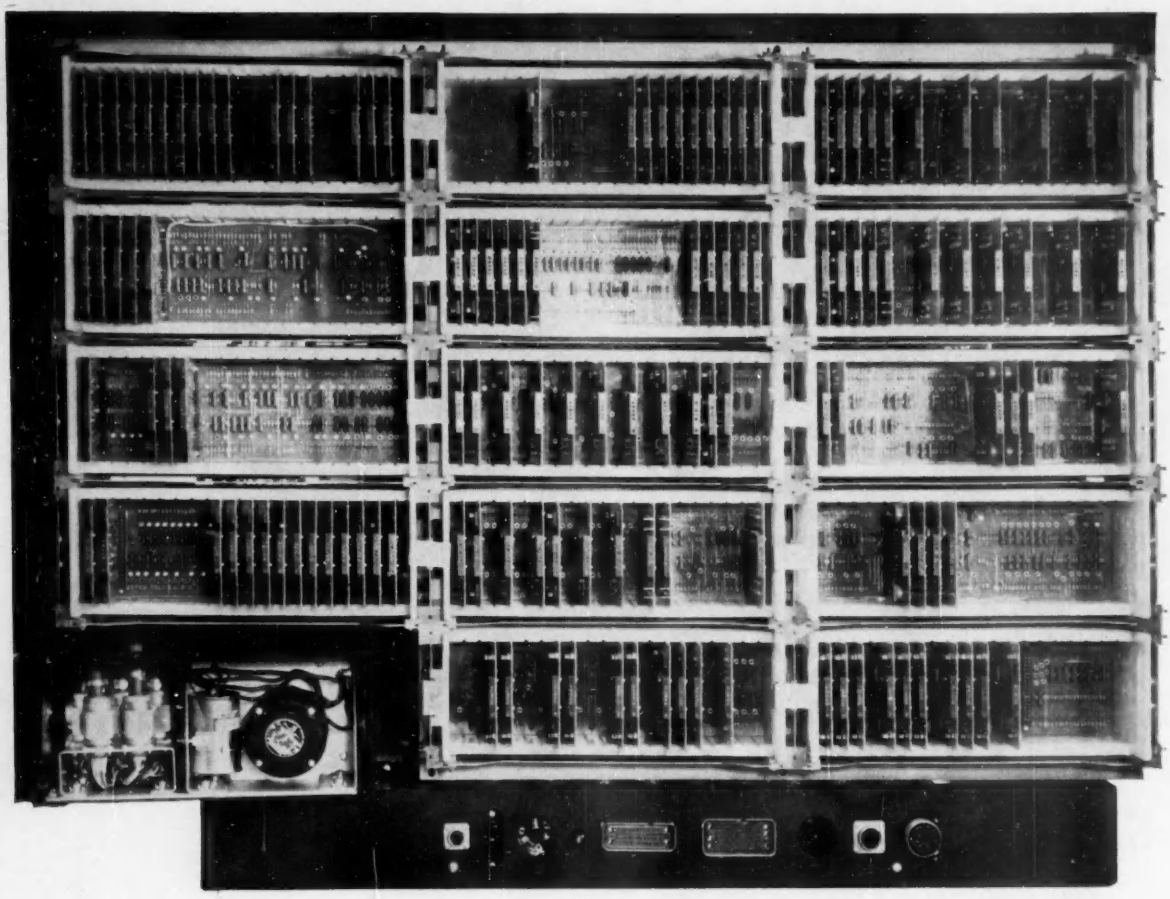
New – 3-pen recording 3 continuous records are simultaneously recorded on one chart, with this new Foxboro 3-pen recorder. Related measurements can be grouped for quick, easy comparison . . . valuable panel space is saved.



Full scale chart The Foxboro 4-inch Consotrol chart, with the same length scale as a 12-inch circular chart, travels vertically from the top. No sagging . . . no misalignment. Pen travels in same direction as circular-case recording pen.



New – indicating tear-off bar Ideal for multi-pen control stations and recorders, this new "see-through" plastic tear-off bar has indicating scales to read second and third variables. Scale colors match pen colors – makes following a process a cinch for the operator.



The Role of
PRODUCT ENGINEERING
in Systems Work

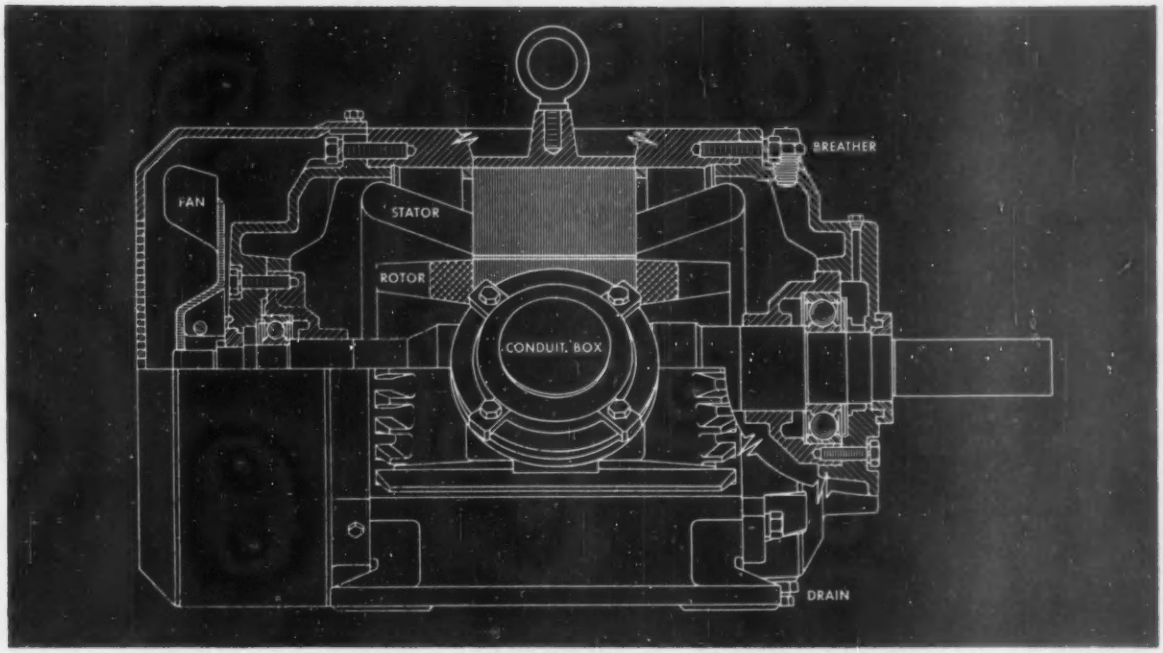
It has become characteristic of modern weapons systems that they are required to operate under severe environmental conditions, as well as to meet stringent weight and space limitations. Moreover, the complexity of many of these systems poses additional difficult reliability problems, while at the same time the increasingly critical consequences that depend on the proper functioning of the typical system logically call for a *higher* degree of reliability than previously achieved. The same is true of certain electronic systems for industrial applications, such as the Ramo-Wooldridge digital control computer, some of whose design features are shown above.

Meeting all of these requirements is in large part the responsibility of product engineering. Generally speaking, product engineering starts with a system or subsystem at the breadboard stage and transforms it into the final product, which in addition to meeting all of the requirements previously stated, must be practical to manufacture and to maintain. Such creative productizing requires the development of ingenious mechanical design features, a thorough knowledge of circuit design and component reliability, and a broad familiarity with materials and manufacturing processes.

At Ramo-Wooldridge, the product engineer is an essential member of the research and development team which has the full responsibility for creating new systems, from the initial theoretical studies on into the manufacturing stage. Engineers experienced in product engineering are invited to explore the variety of openings which exist at Ramo-Wooldridge in such fields as airborne electronic and control systems, communications and navigation systems, digital computers and control systems, and electronic instrumentation and test equipment.

The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA



THIS MOTOR CAN CUT YOUR HAZARDOUS ATMOSPHERE INSURANCE COST

Insuring facilities with electric motors in hazardous atmospheres is generally expensive or impossible without special motors. Reliance has developed a completely new, Underwriters' approved motor design, called explosion-proof, for hazardous locations. In fact this is the only motor design that meets all qualifications for class I, group D and class II, groups E, F and G without requiring modification.

This new motor incorporates all of the outstanding features of the standard Reliance Totally-Protected Motor. In addition, all Reliance Explosion-Proof Motors are built to corrosion-proof standards.

If you would like to have more information on what qualifies a motor for hazardous atmospheres, write for our new Explosion-Proof Motor Bulletin No. B-2409. B-1808

NATIONAL ELECTRICAL CODE CLASSES OF HAZARDOUS LOCATIONS

CLASS I —Those in which flammable gases or vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Group D —Atmospheres containing gasoline, hexane, naphtha, benzine, butane, propane, alcohols, acetone, benzol, lacquer solvent vapors, or natural gas.

CLASS II—Those which are hazardous because of the presence of combustible dust.

Group E —Atmospheres containing dust of aluminum, magnesium, or their commercial alloys.

Group F —Atmospheres containing carbon black, coal or coke dust.

Group G—Atmospheres containing flour, starch or grain dust.

RELIANCE *Totally-Protected* MOTORS

RELIANCE ELECTRIC AND ENGINEERING CO.

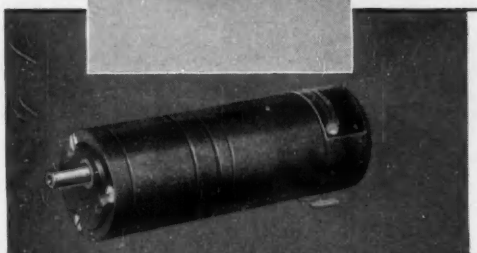
DEPT. 3311A, CLEVELAND 17, OHIO • CANADIAN DIVISION • WELLAND, ONTARIO

Sales Offices and Distributors in Principal Cities

THE MARK OF QUALITY

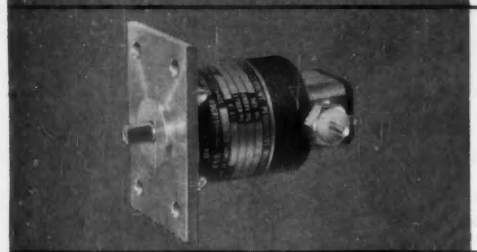
BARBER COLMAN

VERSATILE, RELIABLE ELECTRICAL COMPONENTS FOR YOUR PRODUCTS



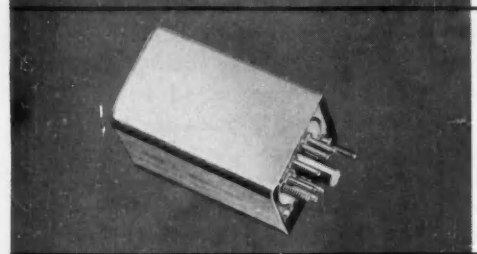
d-c motors

Barber-Colman offers a large variety of compact, high-quality d-c motors for industrial equipment and aircraft control applications. Output up to 1/10 hp . . . available in both permanent magnet and split series types . . . various mountings and speeds. Also offered with gearheads for use as small actuators . . . or equipped with blowers for cooling hot tubes, circuit components, and other confined equipment. Lightweight radio noise filters available for compact, integral mounting on Barber-Colman motors.



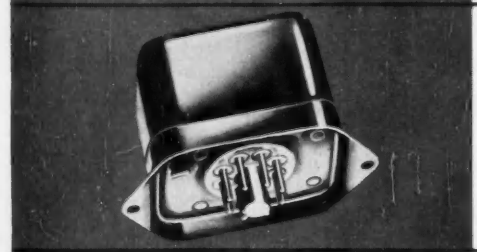
tach generators

For accurate speed indication and servo rate control applications Barber-Colman tach generators supply up to 40 volts per 1,000 rpm within plus or minus 0.5% linearity. Available in several frame sizes with maximum rated outputs up to 7,000 rpm or 100 volts. While standard temperature range is −65 to +200° F, Barber-Colman tach generators have been manufactured for −65 to +500° F ambient.



polarized d-c relays

The Barber-Colman Micropositioner is an ultra-sensitive polarized d-c relay capable of operating on input powers *as low as 40 microwatts.* Available with three types of adjustment: null-seeking . . . symmetrical magnetic-latching . . . or conventional form C snap-acting. Can be operated in excess of 100 cps. Selection of enclosures and mountings. The Micropositioner can also be supplied with integral transistor preamplifiers, greatly reducing the input required for contact operation.



choppers

The Barber-Colman Microverter is the new ac-dc chopper that features extremely low driving power . . . low noise level . . . excellent stability . . . long contact life. It can be used to convert a low-level d-c signal, such as 10 microvolts produced by thermocouples and photocells, into a low-level a-c signal which can be further amplified to operate control apparatus. The Microverter can also be used as a synchronous rectifier to convert low-level a-c signals to d-c without loss. Another important field of application is chopper-stabilized operational amplifiers where zero drift is important.



resonant relays

The Barber-Colman JYZA resonant relay is characterized especially by its low operating power and narrow band width. Coil impedance is high enough to be operated in the plate circuit of a vacuum tube without impedance matching devices. These relays can be supplied tuned to any frequency between 115 and 400 cps. Units have been built to resonate as low as 16-⅔ cps. Band width varies from approximately plus or minus 0.5% to plus or minus 1% depending on input and calibrated frequency.

TECHNICAL BULLETINS AVAILABLE on all of the above products. Write today for copies.

BARBER-COLMAN COMPANY

Dept. W, 1848 Rock Street, Rockford, Illinois



SR-4® LOAD CELLS OFFER YOU NEW ACCURACY—EASE—ECONOMY IN ALL INDUSTRIAL WEIGHING AND PROCESSING

Baldwin SR-4 Load Cells end the costly task of moving loads to and from a weighing unit. Now weigh right in process! Compact Baldwin transducers will measure any tension or compression force—shaft or jet engine thrust—cable tension; determine center of gravity, weight and balance. The applications are virtually unlimited. Weigh loads at rest or in motion. Measurements are accurate to better than ±1/4%; repeatability is better than ±1/10%.

Standard Baldwin SR-4 Load Cells range in capacity from 50 to 200,000 lb. The varying electrical signal from the SR-4 Bonded Wire Strain Gage, basic component of the load cell, can be fed to a wide variety of Baldwin recording or computing equipment.

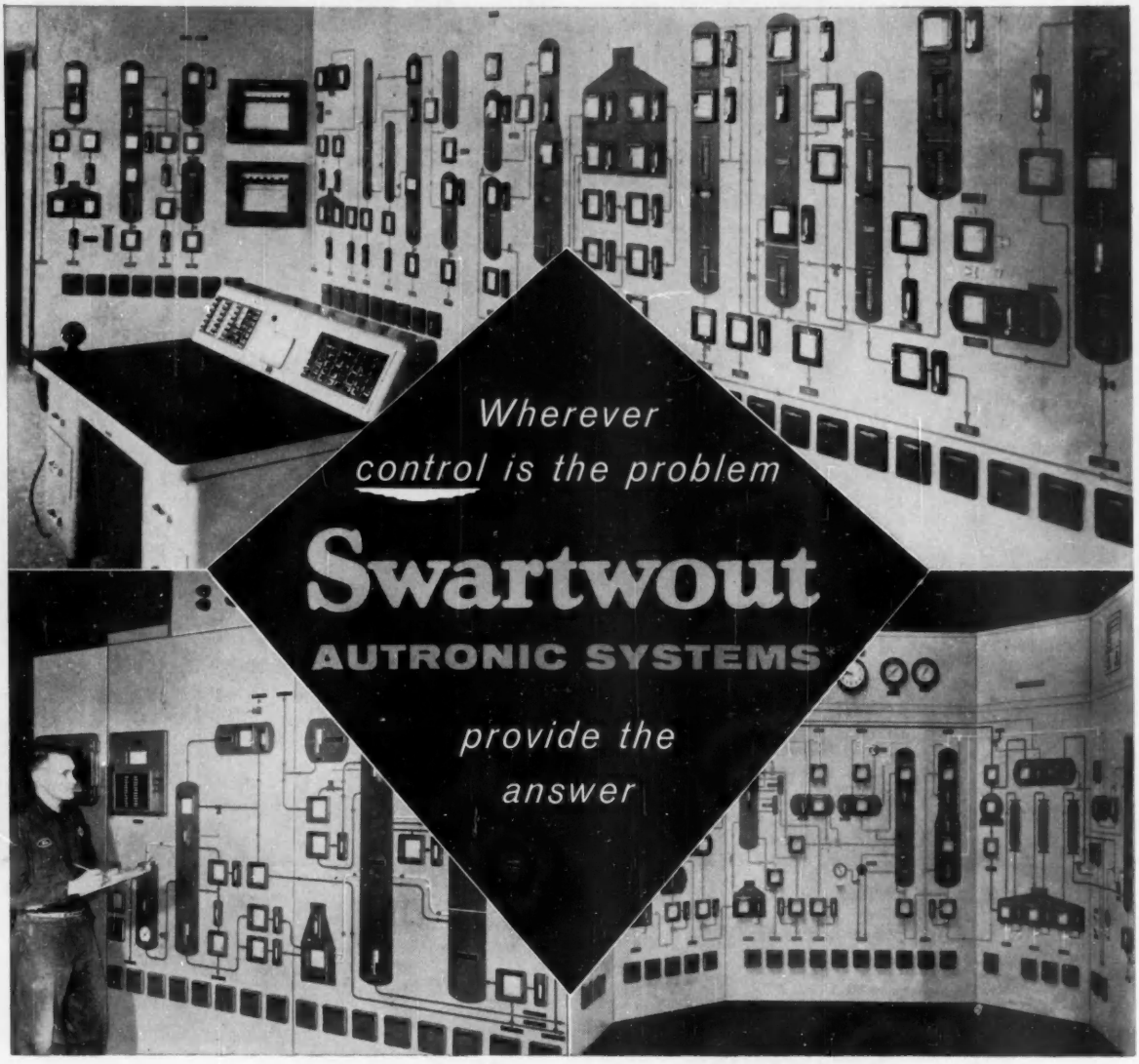
Whatever your weighing problem, a B-L-H representative can help you. For more information, write today for your free copy of Bulletin 4301 on SR-4 Load Cells.

BALDWIN · LIMA · HAMILTON

Electronics & Instrumentation Division

Waltham, Mass.

SR-4® strain gages • Transducers • Testing machines



If control (and/or recording and/or indicating) is *your* problem, Autronic systems or components can provide the answer—rapidly, accurately, economically. For Swartwout Autronic systems are daily solving instrumentation problems *just like yours* in installations everywhere.

Refining . . . atomic . . . chemical . . . pipeline . . . food—in the United States, Canada and overseas—Autronic controls are rapidly obsoleting all other instrumentation systems.

You'll go all-electronic eventually—go Autronic now with Swartwout, pioneer and leader in miniature electronic controls.

*Names of installations illustrated available on request. Or better still, call in your Swartwout representative for a consultation.

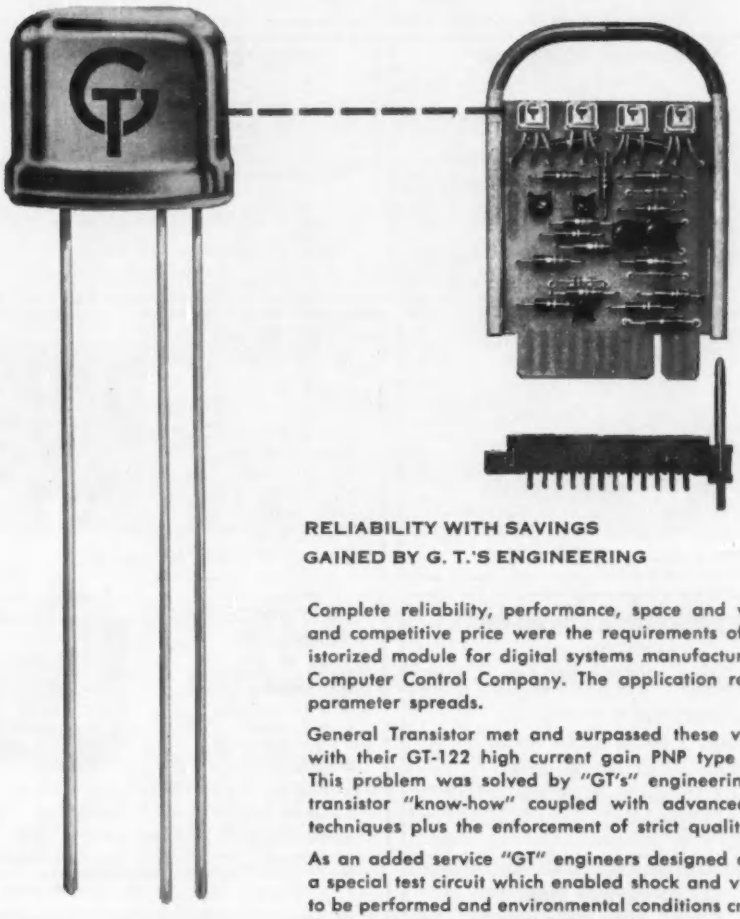
AA-4500

Swartwout *Autronic*® CONTROL SYSTEM

THE SWARTWOUT COMPANY • 18511 EUCLID AVENUE • CLEVELAND 12, OHIO

GENERAL TRANSISTOR

MEETS NARROW PARAMETER SPECS FOR COMPUTER CONTROL COMPANY'S ONE SHOT MULTIVIBRATOR



RELIABILITY WITH SAVINGS GAINED BY G. T.'S ENGINEERING

Complete reliability, performance, space and weight limits and competitive price were the requirements of this transistorized module for digital systems manufactured by the Computer Control Company. The application required narrow parameter spreads.

General Transistor met and surpassed these very tight specs with their GT-122 high current gain PNP type transistor. This problem was solved by "GT's" engineering skill and transistor "know-how" coupled with advanced production techniques plus the enforcement of strict quality controls.

As an added service "GT" engineers designed and constructed a special test circuit which enabled shock and vibration tests to be performed and environmental conditions created to assure the customer complete reliability under extreme conditions.

This is just one more example of why **General Transistor is the fastest growing name in transistors.**

Send today for complete technical data and specifications.

GENERAL TRANSISTOR
CORPORATION

91-27 138TH PLACE
JAMAICA 35. NEW YORK

FREQUENCY STANDARDS



*3⅛" high
400 - 1000 cy.

PRECISION FORK UNIT
TYPE 50

Size 1" dia. x 3¾" H. Wght., 4 oz.*

Frequencies: 240 to 1000 cycles
Accuracies:—
Type 50 (±.02% at —65° to 85°C)
Type R50 (±.002% at 15° to 35°C)
Double triode and 5 pigtail parts required
Input, Tube heater voltage and B voltage
Output, approx. 5V into 200,000 ohms

FREQUENCY STANDARD
TYPE 50L



Size 3¾" x 4½" x 5½" High
Weight, 2 lbs.

Frequencies: 50, 60, 75 or 100 cycles
Accuracies:—
Type 50L (±.02% at —65° to 85°C)
Type R50L (±.002% at 15° to 35°C)
Output, 3V into 200,000 ohms
Input, 150 to 300V, B (6V at .6 amps.)



*3½" high
400 to 500 cy.
optional

PRECISION FORK UNIT
TYPE 2003

Size 1½" dia. x 4½" H. Wght. 8 oz.*

Frequencies: 200 to 4000 cycles
Accuracies:—
Type 2003 (±.02% at —65° to 85°C)
Type R2003 (±.002% at 15° to 35°C)
Type W2003 (±.005% at —65° to 85°C)
Double triode and 5 pigtail parts required
Input and output same as Type 50, above

FREQUENCY STANDARD
TYPE 2005



Size, 8" x 8" x 7¼" High
Weight, 14 lbs.

Frequencies: 50 to 400 cycles
(Specify)
Accuracy: ±.001% from 20° to 30°C
Output, 10 Watts at 115 Volts
Input, 115V. (50 to 400 cycles)

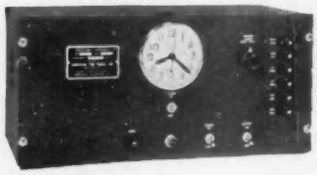


FREQUENCY STANDARD
TYPE 2007T
TRANSISTORIZED

Size 1½" dia. x 4½" H. Wght. 7 ozs.*

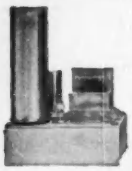
Frequencies: 240 to 1000 cycles
Accuracies:—Same as 2003, above
Type 2007S—Silicon type
Input, 28V.
Output, Multitap, 75 to 100,000 ohms
*3½" in 2007S, 400 to 800 cycles.

FREQUENCY STANDARD
TYPE 2121A



Size
8¾" x 19" panel
Weight, 25 lbs.

Output: 115V
60 cycles, 10 Watt
Accuracy:
±.001% from 20° to 30°C
Input, 115V (50 to 400 cycles)



FREQUENCY STANDARD
TYPE 2001-2

Size 3¾" x 4½" x 6" H., Wght. 26 oz.

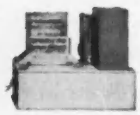
Frequencies: 200 to 3000 cycles
Accuracy: ±.001% at 20° to 30°C
Output: 5V. at 250,000 ohms
Input: Heater voltage, 6.3 - 12 - 28
B voltage, 100 to 300 V., at 5 to 10 ma.

FREQUENCY STANDARD
TYPE 2111C



Size, with cover
10" x 17" x 9" H.
Panel model
10" x 19" x 8¾" H.
Weight, 25 lbs.

Frequencies: 50 to 1000 cycles
Accuracy: (±.002% at 15° to 35°C)
Output: 115V, 75W. Input: 115V, 50 to 75 cycles.



ACCESSORY UNITS
for TYPE 2001-2

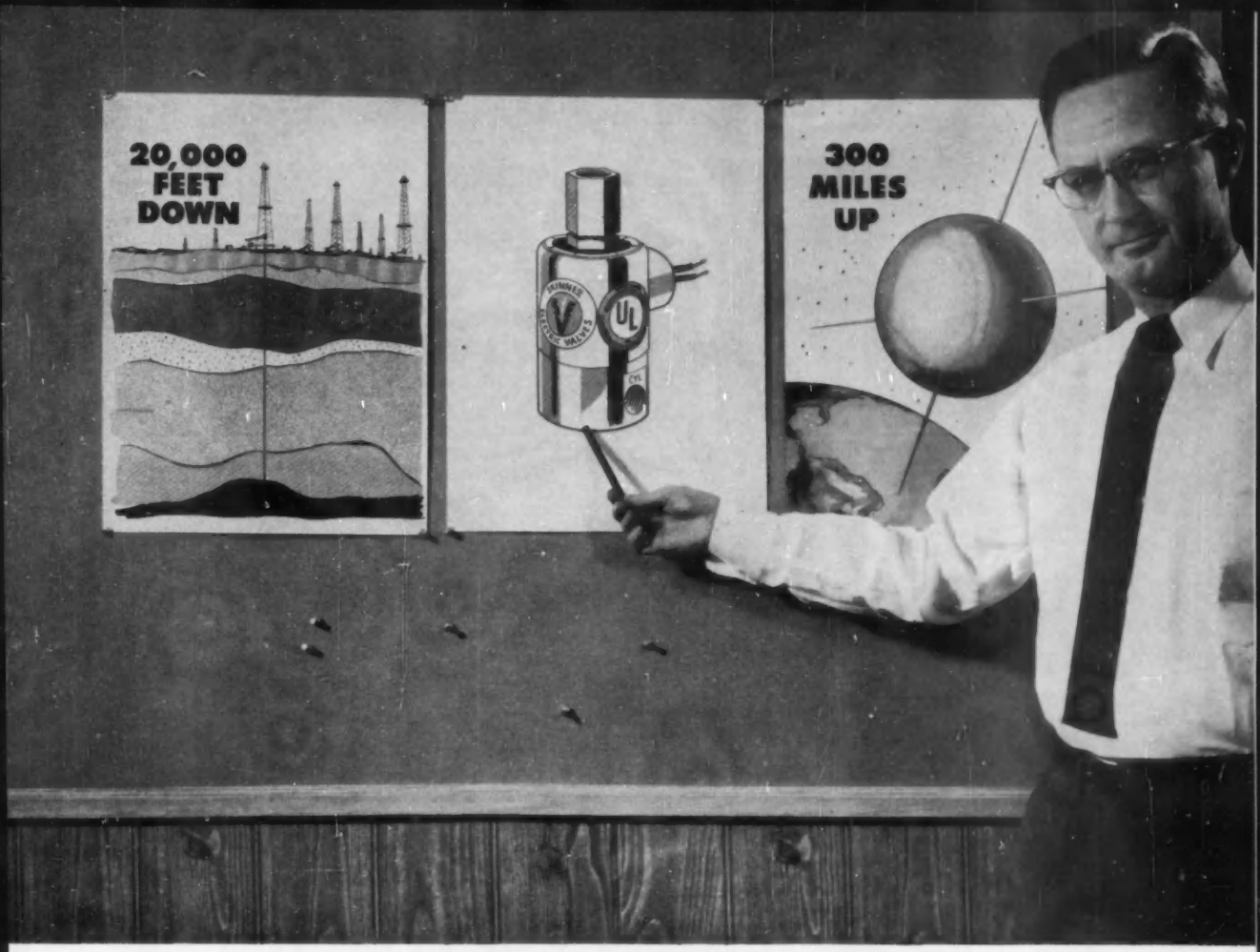
L—For low frequencies
multi-vibrator type, 40-200 cy.
D—For low frequencies
counter type, 40-200 cy.
H—For high freqs, up to 20 KC.
M—Power Amplifier, 2W output.
P—Power supply.

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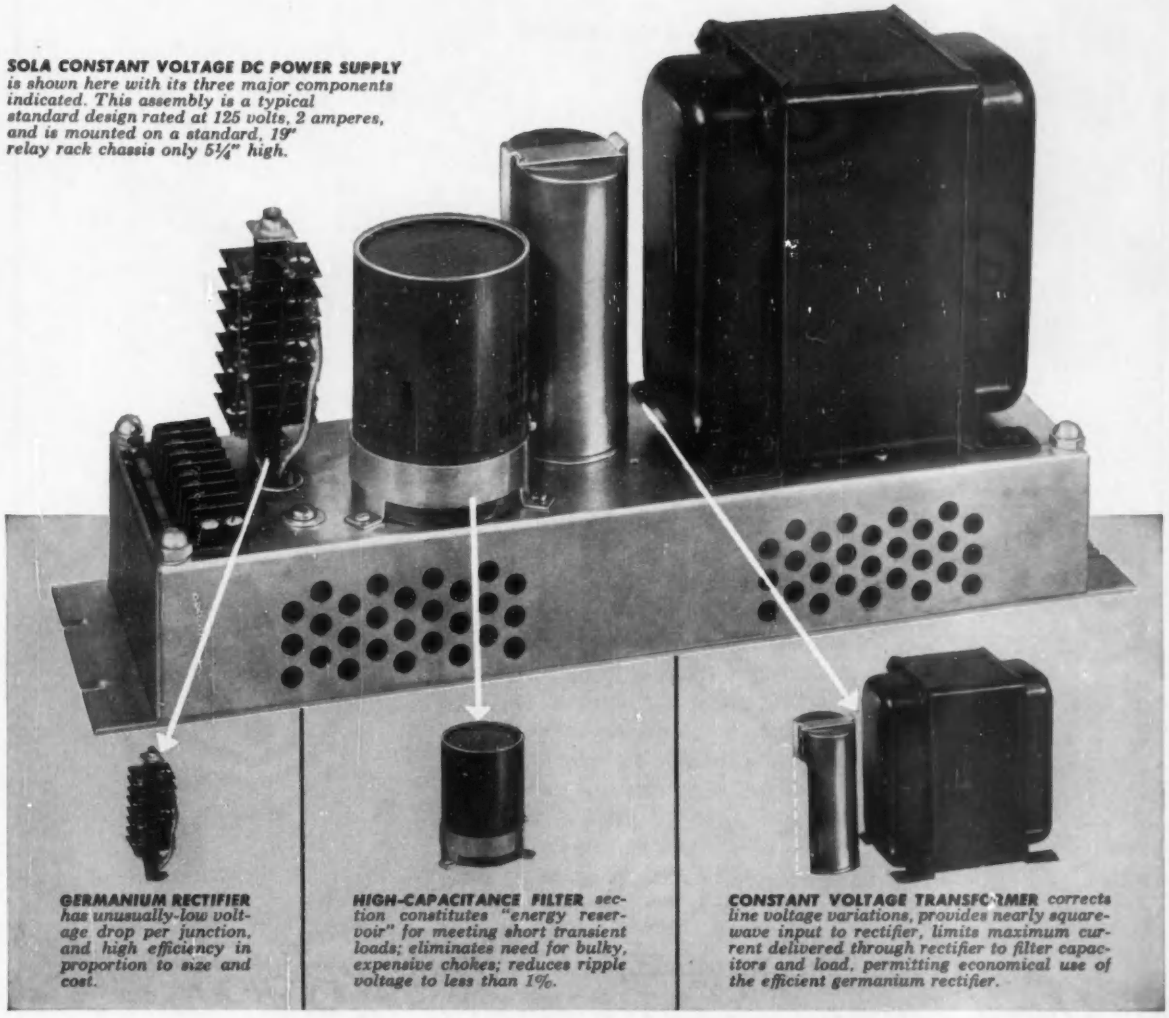


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SOLA CONSTANT VOLTAGE DC POWER SUPPLY *is shown here with its three major components indicated. This assembly is a typical standard design rated at 125 volts, 2 amperes, and is mounted on a standard, 19" relay rack chassis only 5¼" high.*



GERMANIUM RECTIFIER *has unusually-low voltage drop per junction, and high efficiency in proportion to size and cost.*

HIGH-CAPACITANCE FILTER *section constitutes "energy reservoir" for meeting short transient loads; eliminates need for bulky, expensive chokes; reduces ripple voltage to less than 1%.*

CONSTANT VOLTAGE TRANSFORMER *corrects line voltage variations, provides nearly square-wave input to rectifier, limits maximum current delivered through rectifier to filter capacitors and load, permitting economical use of the efficient germanium rectifier.*

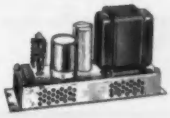
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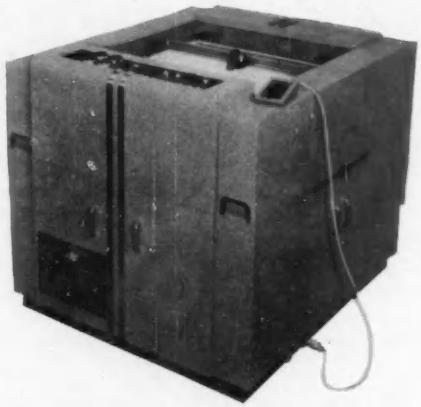
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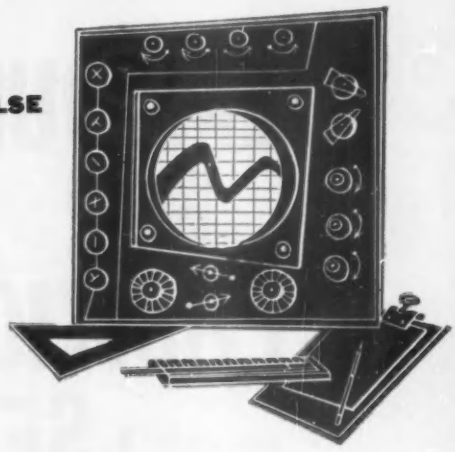
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Budget Pinch Whittles Military R&D

Military research and development threatens to slow down appreciably as a result of the Defense Department's budget troubles (CtE, Oct. '57, p. 52). Military planners see in R&D work an easy way to make quick cuts in expenditures: there's no large dollar volume production involved and much of the research is spread around in small contracts. That makes it easy to cancel this work quietly.

R&D feels the bite

But these "quiet" cuts in R&D will hurt a lot of control companies, particularly the small ones who have specialized in this kind of work as a stepping stone to establishing a reputation for systems engineering. A number of them are living on government contracts. To them, the cutbacks could be fatal.

Instrument companies will feel the bite, too. Second heaviest expenditure in R&D work is usually for instrumentation (first is for labor of scientists, engineers and technicians).

Another reason why control companies will feel the brunt of these cuts so heavily is because so much of the military R&D is in missiles and aircraft—areas in which control plays a leading role. The first big bites were in the aviation field: the Navaho, Republic Aircraft's F-103 and the Navy's surface-to-surface missile Triton were among the early casualties.

The box score

Of the three services, only the Navy appears to be set to carry out its R&D plans for fiscal 1958. The Navy received practically all the new R&D money it asked for: $505 million (up slightly over 1957's $492 millions). Army R&D obligational authority was cut from $410 million in 1957 to $400 million in fiscal 1958. But even this $10 million dollar reduction will mean a juggling of plans. As of now, only a few areas, such as medical research, are safe.

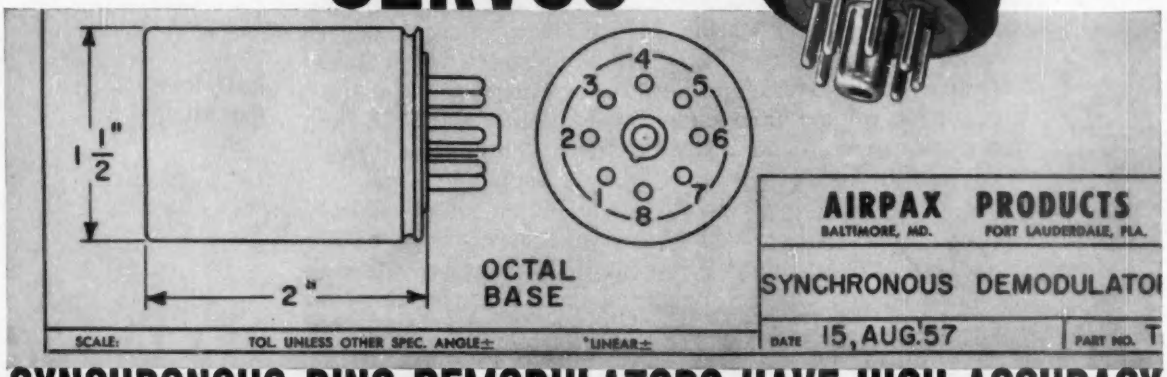
The Air Force R&D program was hurt the most, possibly because it was the most ambitious of all. Budget specialists have to prune a full 8 percent from USAF R&D spending this year. To do this, Washington observers expect the Air Research & Development Command to realign its facilities—merging some, curtailing others and eliminating still others.

Overhead eats up funds

One problem that bothers the Air Force is the way its overhead eats up big chunks of funds. For example, of its $661 million received for fiscal 1958 R&D, over $300 million will go for operation and management—the housekeeping costs of ARDC installations. Most of the rest will pay for current

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Input: Modulated 400 CPS not to exceed 40 RMS volts.

Output: Unfiltered polarity reversible DC into 125-ohm load. With 1 RMS Volt Input the output is:

Type Number	Output Current in Microamperes
D-5170	240
D-5171	180

These outputs are within ±10% of specified values, and are linear within 3% for inputs below 1 volt for Type D-5170 and below 3 volts for Type D-5171.

Reference: 26 ±2.6 RMS volts at 400 ±40 CPS at about 3.2 ma.

Stability: 5% or better.

Zero Error: Less than ±5 microamperes output into 125-ohm load.

Temperature: —55 C to +85 C.

Shock and Vibration: 30 G shock for 11 milliseconds and vibrations of 10 G from 10 to 2000 CPS in all directions.

Enclosure: Hermetically sealed with octal-pin base, weight about 7 oz., seated height 2 inches, diameter 1½ inches.

AIRPAX PRODUCTS CO., CENTRAL ENGINEERING DIV., CITY OF PLANTATION, FORT LAUDERDALE, FLORIDA

work, leaving very little for new research—a bulwark in the past.

Therefore the big blow to research and development will come from the Air Force's inability to start new projects rather than the dropping of existing work. Probably where such a policy has hurt most so far is in the Air Force Office of Scientific Research which has 650 contracts spread around the country. In October, these contractors were told to tread water and not to incur any big expenses. Some of the contracts will not be renewed; others are being watered down to the standstill point.

Universities pinched

Although AFOSR's budget is only $16 million—most of its contracts are relatively small (mathematical average about $250,000) compared to other government spending—still, the threat to AFOSR's projects has evoked a number of alarms. Universities, in particular, claim cutbacks will slash deep into basic research, ultimately harm the overall defense program.

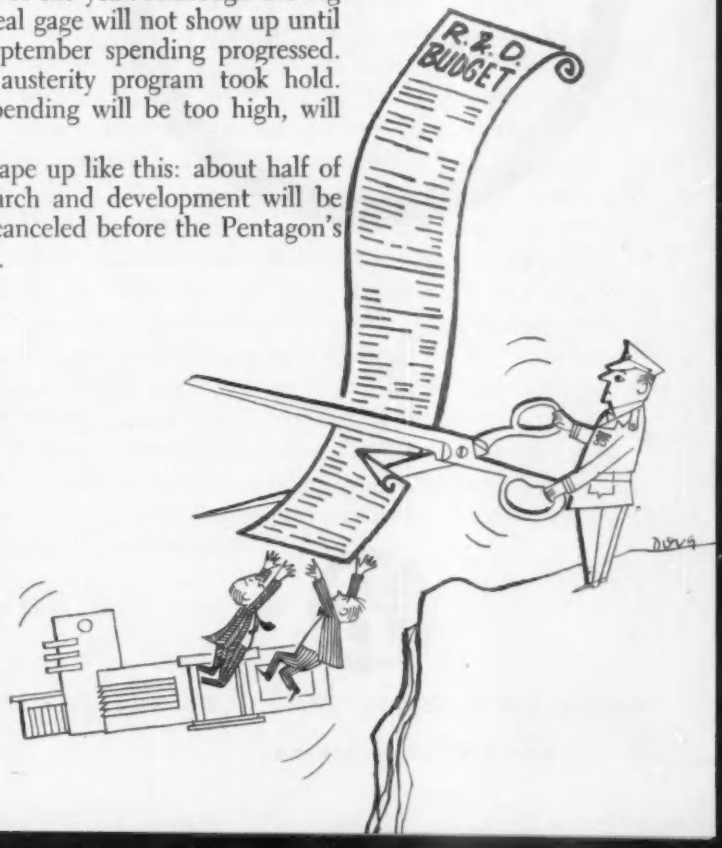
But the universities got little support from former Defense Secretary Charles E. Wilson. Queried specifically about the concern of universities, Wilson said, "Some of this research and development ought to be finished someday . . . otherwise, all you are doing is underwriting a subsidy for some university . . ."

Another aspect of R&D that may be affected by the military's precarious dollar position is that portion carried on by private industry with its own money. Companies will be less likely to pump money into developing military-type equipment with slimmer odds that it can be sold to a retrenched Pentagon.

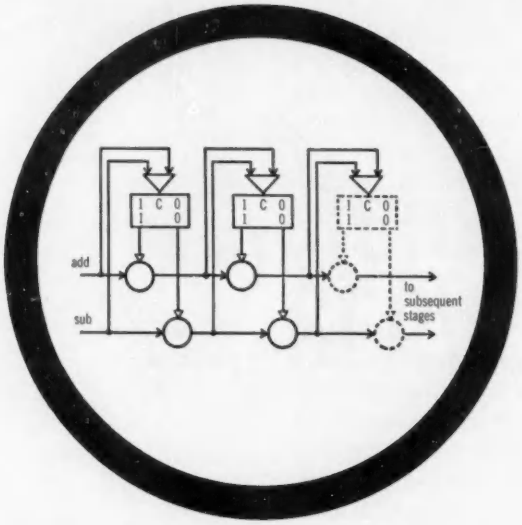
A clearcut pattern for military R&D spending will probably not emerge much before the first of the year. Although the big cuts have been announced, the real gage will not show up until Pentagon officials know how September spending progressed. That was the first month the austerity program took hold. But the first guesses are that spending will be too high, will have to be cut back even more.

Prospects for military R&D shape up like this: about half of the 3,000-odd contracts in research and development will be scaled down, and many will be canceled before the Pentagon's economy drive runs out of steam.

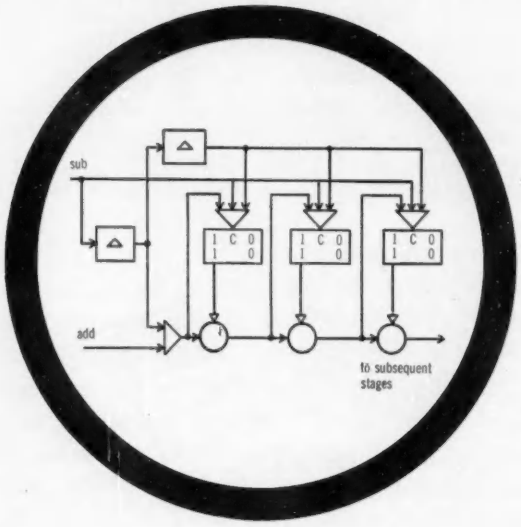
It's doubtful if the Russian-launched "sputnik" will have any immediate effect on the military R&D picture, despite agitation for some kind of satellite "crash" program. As one Washington observer said, "It would be different if Congress were in session; you can be sure it would have appropriated more funds for space research." But one possibility for next year: a Manhattan-type project for space and missile R&D.



Burroughs digital techniques for the laboratory



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The two two-way counters illustrated are ideal examples of solutions readily proved with Burroughs Pulse Control Equipment. With either solution in block diagram form, the designer selects the proper Burroughs "blocks", sets them up in a standard rack, and interconnects them according to the flow lines in the diagram itself. Converting to the other counter design takes little more time than does redrawing the block diagram.

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Control ENGINEERING
NOVEMBER 1957

Prepare Now for the Technician Gap

We believe that a pressing technician shortage will develop in the measurement and control field as a direct result of an advance toward the greatest capital goods boom in history, in the mid-60's. But we also believe that you can do something about it now. McGraw-Hill's Dept. of Economics expects that private industry's spending of $7-8 billions on research and development per year will spark the advance in three phases:

- next few years.....new components and control devices
- beginning in '59 or '60.....new machines using the new control devices
- 1965.....new processes and manufacturing plants

Many control engineers will have the pleasure of working on stimulating problems of systems design and application raised by the R&D. But the success of their work and the entire advance will suffer unless we develop enough control technicians to make the systems work and to keep them working.

The control technician needed for these systems will have to be well-grounded in the fundamental sciences, in mathematics up through calculus, and in the principles of measurement and control. Where will you find such a man? The Foundation for Instrumentation Education and Research estimates that only 2,500 qualified control technicians, including about 350 graduates of technical institutes, become available each year. FIER found that 23 of the 45 technical institutes that responded to a survey have courses in some aspect of measurement and control, but that only four give complete programs for the control technician, and that of these one is specialized to the paper industry.

Major teaching lacks mentioned most frequently by the technical institutes were: laboratory equipment (50 per cent), text material (26 per cent), and adequate instructors (24 per cent). But most disturbing was the complaint that industry has not made clear its needs for control technicians. This may be because the need does not seem urgent now, but we are convinced that it will become increasingly urgent during the next eight years. If you agree with us, state your needs in terms of number of technicians, when you will need them, and the skills they must have. Tell the deans of technical institutes, the editor of this magazine, and the director of FIER*.

THE EDITORS

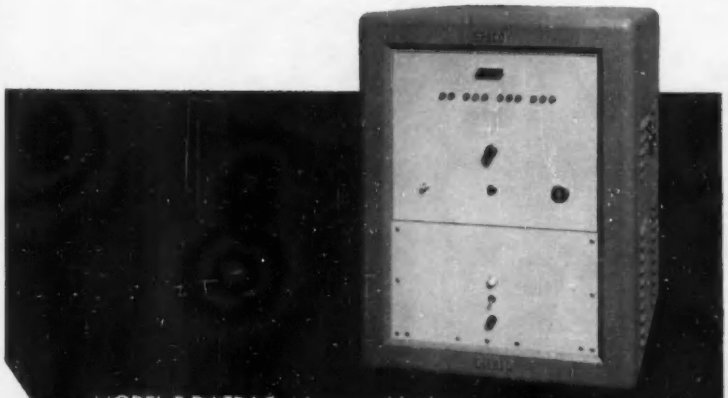
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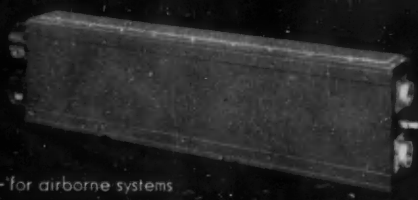
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A tool designed specifically for industry, the TRANSICON DATRAC, utilizing the latest proven semiconductor and magnetic circuit techniques (**it employs no vacuum tubes**), features:

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- conversion rate: any from 5 μsec./bit to ∞
- absolute accuracy: .05%*
- bi-polar input with ±10 volts full scale
- in-line visual readout optional
- 3-4 decimal digit and 12-16 bit straight binary models
- absolute value output indication
- fully reversible

An equipment of proven accuracy and reliability for airborne systems, the MINIDATRAC, qualifying under the applicable portions of MIL-E-5272 and MIL-E-5400, features .1%* accuracy with a conversion rate of 2 μsec./bit, capable of inflight digital recording or pulse code modulated telemetery.

* ±½ least significant digit.

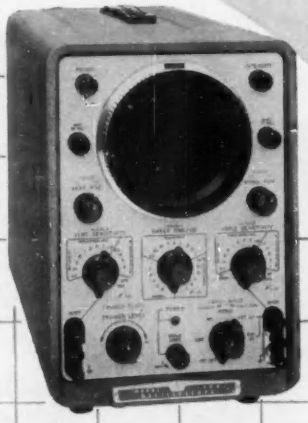
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AT WHITE SANDS

they track missiles in the lab and on the range

LEWIS H. YOUNG, Control Engineering

Simulation of flight and environment has earned a new role in test procedures; but the missile shoot still is the last word for performance. CONTROL ENGINEERING visited the U. S.'s first—and still busiest — missile proving ground at White Sands, N. M. for a first-hand report on what missile testers are doing and what techniques they are readying for the future.

Missile testing today at the U.S. Army's White Sands Proving Ground combines simulated shoots with real firings to turn out complete studies of missile systems. As a supplementary technique, simulation in the laboratory supplies information that can't be obtained by any number of actual firings on a range.

When WSPG was established in 1945 to study captured German V-2 rockets, military men believed the only sure way to test a missile was to fire it and then watch it closely. That's why the Army's Ordnance Dept. selected for the U.S.'s first missile test range an isolated desert tract in New Mexico, 55 miles north of El Paso and sandwiched between the San Andres and Sacramento mountain ranges. But today at the New Mexico missile center, the military is getting as much valuable scientific information by simulating firings in the laboratory as from actual range firings. Activity in "make believe" flights has become so great that it has demanded a special flight simulation laboratory, soon to be built at the Army proving ground.

I. Simulation makes its way

Simulating missile performance is not a brand new technique. The Germans first tried it on a small scale under V-2 scientist Gunther Hintze, just before World War II ended. Hintze's efforts were aimed at testing V-2 components. Even though he was limited by the newness of computer technology and a lack of suitable equipment, the German scientist had some success putting components through their paces before they were assembled.

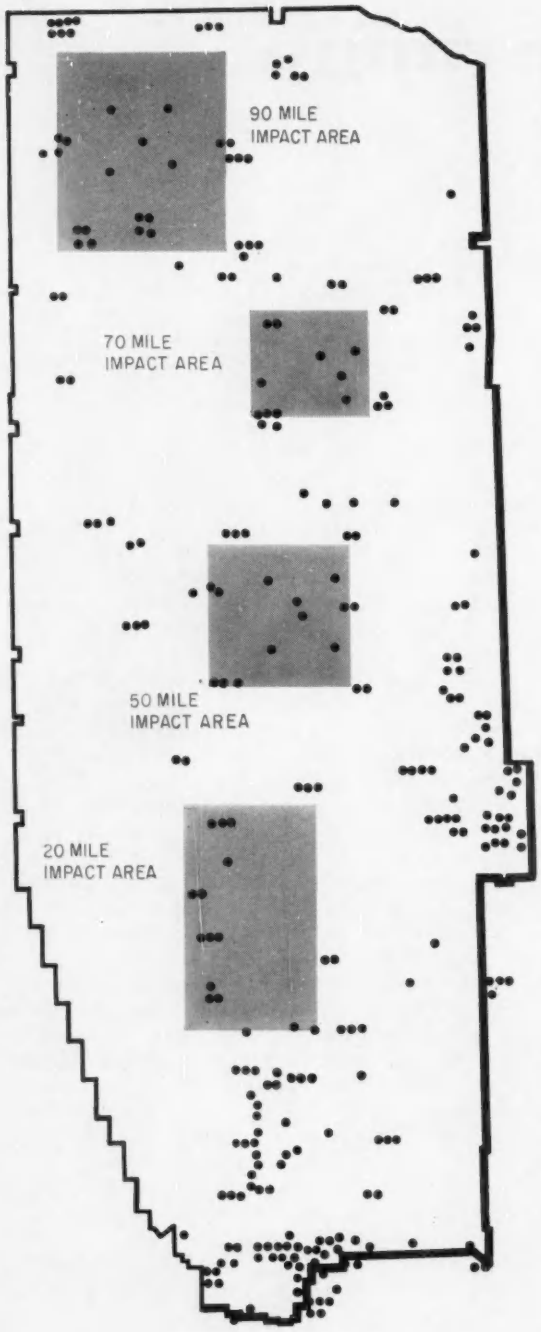
It is this same Hintze—now head of White Sands' Flight Simulation Laboratory in the Electro-Mechanical Laboratories of the Ordnance Mission—who is spearheading the simulation work at WSPG.

Conditions for simulating missile firings suddenly became ripe in 1954, when a combination of factors complicated the missile situation. First off, the U.S. missile program had finally shifted into high gear: as new missiles were delivered to the proving grounds, test firings had to be stepped up so that facilities at WSPG were taxed to the limit. At the same time, operating characteristics of missiles had improved so markedly that new "birds" were reaching supersonic speeds and attaining record altitudes. And range safety was becoming more worrisome: one missile had already performed a "wrong-way Corrigan" and almost fractured friendly relations between Mexico and U.S. by landing too near the tourist city of Juarez.

As one way to help to see these problems more clearly, Hintze (then a senior scientist at White Sands) suggested flight simulation techniques. He offered three convincing reasons:

• Range safety—Even approximate simulation would indicate whether a planned firing would exceed

White Sands Proving Ground is 40 miles wide and 100 miles long. Colored areas are target areas; black circles indicate location of range instrumentation; optical, radar, telemetry or electronic. WSPG is U. S.' only land-locked missile range that permits easy recovery of test vehicles after firing.



safety limits, would provide range officers with a projected trajectory in advance of the firing, and would point out maneuvers in the planned test that might create a safety hazard, making such operations subject to particularly careful scrutiny.

- Economy—A test firing of a guided missile costs in the neighborhood of a million dollars. Bigger missiles (like ICBM) cost many times more. And the range scientists are limited by the number of missiles that are available. With simulation techniques, they can perform hundreds of "flights" and thousands of tests—for a few hundred dollars.
- Planned testing—Simulation before firing would help engineers and scientists plan an actual test by pinpointing critical areas or areas that should be studied closely. In addition, range firings at White Sands always subject the missile to the same initial atmospheric conditions—hot, dry, sandy, sunny weather (the sun shines an average of 350 days a year) at an altitude of 4,000 ft—while simulated firings superimpose a variety of conditions.

Hintze's arguments must have impressed Ordnance officers, because he got an almost immediate OK in April 1954. It took another year to get equipment installed and studies under way. For analog simulation, WSPG bought an Electronic Associates analog computer, with 250 operational amplifiers; for digital work, a Univac 1103.

The first simulation studies conducted in 1955 were so effective that simulation was accepted as standard operating procedures for all future tests. Proof of this effectiveness is mirrored in the quick acceptance of simulation information by missile project officers who are responsible for the success or failure of actual range firings. Now these same project officers are swamping the flight simulation group with requests for more and more data.

Approach to simulation

In the procedures that Hintze has worked out, the first step is to translate the physical systems of the missile into a clear mathematical formulation. The system approach is still another advantage of simulation: It permits an overall evaluation of the system and basically, scientists are interested in how changing performance characteristics of components affect overall system performance. To do this, scientists set up two groups of expressions:

1) Equations of motion which describe the movement of the missile in space. Two sets are of interest, one describing translatory motion, the other rotational motion. These equations are also known as force or moment equations because they indicate all the forces (such as thrust, drag, lift, or gravitational force) and moments (such as pitching and yawing moments) which act on the missile as it flies through space.

2) Equations for the electronic, mechanical, and hydraulic components, expressed as transfer functions—which relate output of the component to

the input. A typical component is the servo system that drives the rudder fins of the Corporal missile: a relationship is established between the incoming electronic signal and the actual rudder deflection.

After the equations are set up, additional environmental and design characteristics are added. Example: the aerodynamic characteristics dependent on the atmosphere as well as the configuration of the missile which are incorporated in the equation for pitching moment.

When the basic equations have been refined, they are ready to be programmed (for digital computers) or mechanized (for analog computers). Problems that involve physical phenomena with a fast changing rate, such as the response of the missile rudders, are best solved on an analog computer capable of handling in real time these high frequency dynamic characteristics. Slower changing processes, whose computation requires a high degree of accuracy, such as the motion of a missile along its trajectory in flight, are calculated on the digital computer.

Simulation vs. real flights

Some simplifying assumptions have to be incorporated into the mathematical models of the missile systems. That's because scientists just don't know enough about certain phenomena, and inclusion of other factors would complicate the equations, making them impossible to solve. But even so, Hintze claims that his simulation figures rarely vary more than 2 to 5 percent from results obtained from actual firings.

And that's the next step: to try and reproduce an actual firing exactly on the computer-simulator. To detect the differences between simulated and real flights, several range firings are conducted under carefully controlled initial conditions. Then an analysis is made of both the simulated flight and the real flight, noting where deviations occurred. The trick is to find out why the flights are different.



WSPG cantonment area, which contains administration offices, missile preparation buildings, data reduction facilities and other laboratories, is located at the foot of the Organ Mountains. Missile park in front of WSPG Headquarters building contains samples of each unclassified missile tested since WSPG was opened in 1945.

Here's an example. During early tests on the Nike missile, analysts noted that the simulated trajectory came earthward much more rapidly than the missile did when it was actually fired. They finally reasoned that Nike has command limiting circuits built into its guidance system so that rate of response to commands is reduced as rocket power is exhausted; there was no such qualification in the simulation equations. When a similar circuit was introduced in mathematical form to the mathematical model, simulated flights then followed real flights closely.

Hintze says that once the mathematical model of a missile system has been correlated with real flight data, there is no limit to the kind of testing you can do in simulation. One favorite procedure is to determine the whole envelope of test for a missile. In a few days the simulator group can run a missile through make-believe firings that cover the



Gunther Hintze, in charge of the Flight Simulation Laboratory, studies a setup on the analog computer. Present capacity of the computer is 250 operational amplifiers. WSPG will double capacity this year, and extend unit to 1,000 amplifiers next year.

DATA PROCESSING TIME

Type Report	Scheduled Time Average
	Days
PDR (Preliminary Data Report)	8.0
Askania	15.0
Radar	16.0
Dovap	30.0
Telemetry	32.0
Miss Distance	25.0
F-46	11.0
Dovap Systems Functions	8.0
Reflection Doppler	11.0
Wind Data	7.0
Austin	5.0
Attitude	24.0
Launcher Data	8.0
Bowen-Knapp	30.0
70 mm	24.0

entire range of possible operating conditions—an operation that would take hundreds of missiles and cost millions of dollars if it were tried on the firing range.

Simulation in the future

Because of the growing demand for simulation at White Sands, Hintze's group has two big projects under way. One is an increase in facilities, the other is a study to refine methods of systems analysis so that phenomena not understood completely now can be incorporated into mathematical models.

White Sands plans a two-step increase in simulation facilities. This year, a new building will be built to house the simulation group. The analog computer capacity will be increased by 250 operational amplifiers, bringing the total to 500. And the Univac 1103 will be replaced by a faster Univac 1103A (or an IBM 704). Next year, analog computer capacity will be increased to 1,000 operational amplifiers; and another Univac 1103A (or an IBM 704) will be added to the digital facilities.

First priority at White Sands in systems analysis research is an attack on the noise problem. As Hintze explains it, "We want to know more about noise and its effect on missile systems. We need a mathematical way to express how noise is generated and how it is propagated throughout a missile system." Another new area of investigation at WSPG is how to treat missile elasticity in the mathematical model. At present, engineers assume that the missile is rigid. But this is a simplification; in reality the missile is elastic. That presents a whole new set of equations covering all the physical phenomena and the interactions of the elastic missile with its guidance and control systems.

Another major step forward in missile analysis is the trend toward three-dimensional mathematical models instead of two-dimensional ones. Simulation work started with the simpler two-dimensional models obtained by reducing the trajectory to two dimensions. But Hintze feels he'll get more accurate results and a more realistic model with a three-dimensional approach. The change complicates the mathematical analysis by one order, but Hintze thinks it's worth it to get increased realism.

Climates made to order

Just recently, scientists and engineers at White Sands have become very conscious of New Mexico's balmy dry climate and the limitations it imposes on missile evaluation. If all missiles were to be launched from the same kind of an area there would be no problem; but the armed services have to know how missiles will operate under weather conditions that range from arctic blasts to equatorial monsoons. To help find out, WSPG has built an environmental laboratory that's capable of duplicating almost any kind of climate. It's another branch of the Ordnance Mission's Electro-Mechanical Lab.

With present facilities a missile or missile components can be subjected to variations of temperature in hot and cold chambers, to the effects of altitudes from sea level to the thin upper atmospheres in altitude chambers, to the attack of fungus in a specially designed mycology laboratory, to the soaking of humidity and moisture in humidity chambers, and to the corrosion of salt fog.

Some equipment is designed to put missile components through a combination of elements. For example, one hot chamber simulates flight in another part of the world by subjecting missiles to temperatures up to 200 deg F, humidity to 100 percent, rain up to 8 in. per hour, and continuous salt spray. Construction recently started on a test chamber that will apply still a different kind of torture to missiles and components—this by simulating a desert sandstorm. The equipment will generate a wind with a velocity up to 3,000 fpm, temperatures from 70 to 170 deg F, and sand density to 1.5 grams per cubic foot, worse than any sandstorm ever reported. Still other environmental tests are imposed by shock and vibration equipment.

Just recently, WSPG has started using a new technique for simulating environmental conditions. Variables of temperature, humidity, and vibration are carefully recorded on magnetic tape during a missile firing. The tape of the real flight becomes the program to control the operation of the environmental test chambers played back through the analog computer. In this way WSPG engineers check out a missile guiding system, for example, by putting it through the rigors of an actual flight before the missile is assembled, varying conditions of temperature, altitude, and vibration in the exact way they would be varied during real flight.

Looking back over two years of simulation experience, White Sands officers find some unexpected advantages have developed. One of the most im-

portant stems from a disadvantage: they haven't really been able to test ground-to-air missiles under realistic conditions. Usually such range tests involve shooting down a radio drone or an obsolete airplane. But as Hintze says, "It's not much of an accomplishment to hit a 250-mph pre-World War II bomber with a modern missile; what we want to know is, can we shoot down an 850-mph supersonic attacking plane? Up to now, White Sands hasn't received any modern jet planes to serve as targets—and it's not likely they will get any in the near future. And that's where simulation gets to play its biggest role. On a computer, we can make simulated attacks on targets flying at any speed we specify".

II. Real flights have the last word

Although simulation plays an essential role in missile testing, there's a limit to the kind of information that such techniques can supply. That's when actual firings are used. A missile shoot helps correlate the mathematical model for further simulation studies and it's the only sure way to spot-check production models of missiles.

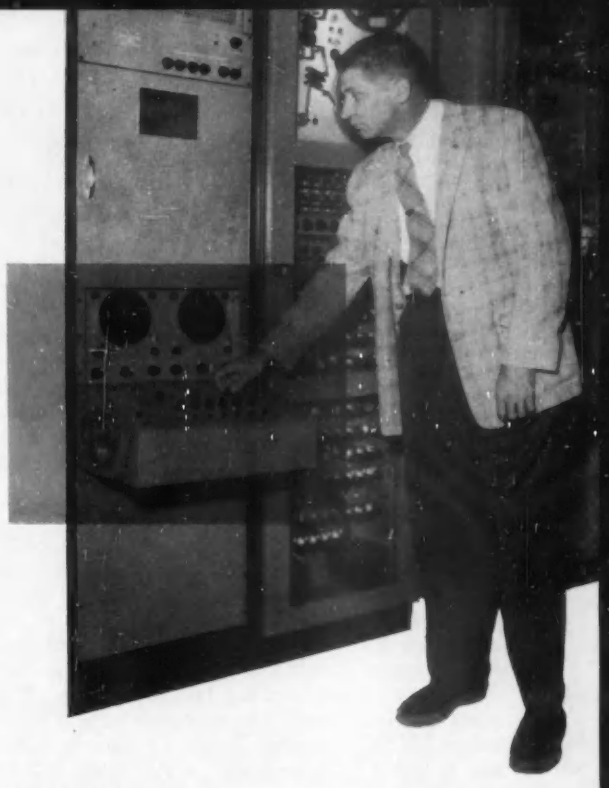
Range operation, data acquisition, and data reduction are the responsibility of the White Sands Integrated Range Mission.

Ben E. Billups, technical director of the Data Reduction Branch, has spent 10 years at White Sands in data acquisition and processing work. In 1947, he remembers, there were only 60 people doing data collection and reduction at WSPG; today there are over 1,200. This 20-fold increase in data-processing personnel mirrors the increase in range instrumentation. Today, there is between $150 and $200 million invested in instrumentation on the White Sands range. The data-gathering devices can be classified as optical, radar, telemetry, or electronic trajectory systems.

Cameras for accuracy

Most accurate information, says Billups, comes from photographic data. Six different kinds of cameras are used at White Sands: 1) Askania Cine-Theodolites, 2) Bowen ribbon-frame, 3) IGORS (Intercept Ground Optical Recorder), 4) tracking telescopes, 5) ballistics cameras, and 6) Mitchell movie cameras.

Although photography supplies precise data, it has some serious shortcomings, so serious that WSPG has an extensive research program to replace the cameras with electronic trajectory systems. Severest limitation of the cameras is the time required to process photographic data. First, the film has to be developed, then the negatives have to be read (the big bottleneck) and finally the data has to be converted to a form that can be used as input to the computer. Even though some mechanical and electronic devices have been developed to speed up the reduction of photographic data, it still takes a formidable amount of time (see table listing number of days to process camera data).



Ben E. Billups, technical director of Data Reduction Group, checks the controls on the new electronic Askania photo reader. Machine reads Askania azimuths at a rate of 10 per second, a big improvement over manual readings.

Askanias—At the present time, the Cine-Theodolite is the key to accurate position determination. WSPG has 57 Askanias zeroed in on its 100-mile range. In a test, six to 40 Askanias will be used. The top number performed in a recent ground-to-air test in which a missile had to feint at one target and attack a second. Cameras were required to track the missile and targets and to supply backup data.

Theodolite stills have always been a roadblock in range-data processing because of the necessity of reading the verniers on each frame. Even a skilled operator can evaluate only two or three frames per minute. Billups' group has just started using a device that speeds up this portion of the job by reading these scales electronically, at a rate of 10 frames per second. To do this, WSPG had to first replace the vernier indicators on the Askanias with an indicator that displayed vertical and horizontal azimuths as a digital code. The reading device, called ORDRAT for Ordnance Dial Reader and Translator, relies on a photocell to read the code, digitizes it, and puts it on magnetic tape. Corrections still have to be read on a second device, but are added to the base reading in the Univac.

Bowens—These high-speed ribbon-frame cameras

are used for determining velocity. They can take 30 to 60 pictures a second, at an exposure of 1/10,000 sec. The Bowen's major limitation is photo-evaluation time, which can be as long as 35 days for a single mission.

IGORS—This special combination of a high-speed Mitchell movie camera (120 frames/sec) with a Fastex camera (2,000 frames/sec) was developed with WSPG help to determine miss calculations, how close a missile comes to an airborne target. Miss distance is an important variable in ground-to-air missiles because many missiles do not have to hit their target to destroy it; if the warhead explodes within a specified distance of the target, it is as effective as a direct hit.

There's been a lot of research expended to develop miss-calculation equipment. Missile project engineers are still not satisfied with the IGOR because it is possible to get the camera and target in such a position that IGOR information turns out to be indeterminant (there's a division by zero). Even close to this point, accuracy falls off quickly. Engineers even developed a target-borne camera system called ITOR (Intercept Target Optical Recorder), but it had a fatal weakness: if the target was hit, all data was lost.

In IGOR, the Mitchell camera is used to plot the flight of the target and the missile. The Fastex camera can time the explosion of the warhead; it does this with an accuracy of 1/1,000 sec.

Tracking telescopes—Another early range development at WSPG involved tracking missiles with "bright-eyed" telescopes to obtain attitude and event data.* The range uses a whole family of these telescopes on gun mounts with standard motion-picture cameras. On a bright, sunny day, this combination can photograph at distances up to 120 miles.

Ballistics cameras—These are fixed-plate cameras that supply the most accurate instrumentation for position determination because they use star photographs for calibration. The camera is opened before flight, and the film records many images of the missile as it moves across its trajectory. However, this technique works best at night; data reduction is a long, tedious job performed manually.

IGOR camera developed for WSPG for miss calculations combines a high speed Mitchell movie camera with a Fastex camera.



Electronic workhorse

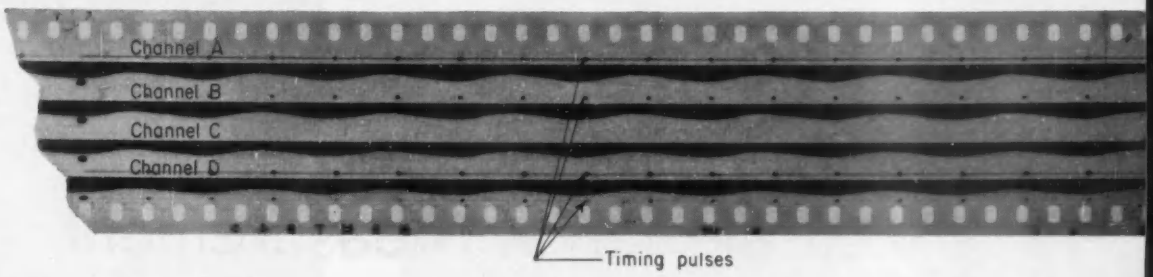
Because of the limitations of photographic techniques, missile instrumentation specialist Billups feels that electronics is going to be the workhorse of the missile range. He thinks electronic systems will be faster—basic digital data can be put on magnetic tape immediately—they'll be more flexible than optical systems, and they'll have fewer limitations (geometry is frequently an optical systems limitation). Today the big problems with electronic systems are: 1) high cost, 2) lack of reliability, and 3) lack of accuracy.

WSPG has been using radar as a tracking device since 1951; it now has seven radar stations, each equipped with enough gear to carry out two missions at the same time. Main uses of radar are to supply directional information to "talk" the more accurate Askania cameras onto targets and to supply range-safety officers with a printed plot of flight as it progresses.

The range also uses radar velocimeters that work like a traffic cop's speed trap. A dish-shaped antenna sends out a sine wave that bounces off the missile in flight and the returning signal is compared to the outgoing signal. Because of the Doppler effect, beats are produced that provide an indication of missile velocity.

Radio telemetry is used widely at White Sands to report back variables as they are detected by a missile in flight. For more accurate results, WSPG has been mounting airborne recorders and oscillographs into missiles in special "coffins" that can survive the shock of missile launching and landing.

But both radar and telemetry have their limitations in missile testing. That's why engineers have been looking for a different kind of electronic system. There's been a lot of development work done in this field, and it takes an interpreter to identify the various techniques from their alphabet-soup designations.



Film from DOVAP installation, one of the first electronic range systems. Dots are timing pulses. Channels A, B, C, and D are beat (Doppler shift) frequencies from receiver stations A, B, C, and D.

One of the first was DOVAP (that's Doppler Velocity and Position), which has been under study at WSPG since 1946 and in production since 1955. In this system, a commercial ground transmitter sends out a sine wave to down range stations and the missile. When the signal is received by the missile, it passes into a frequency doubler and is then retransmitted. At each DOVAP range station, there are two receivers: one picks up the original signal, the other receives the rebroadcast signal. Both signals are then fed into a mixer and the resultant beats indicate distance of the station from the missile. It takes from four to seven such stations to locate the missile in space, using trigonometric equations.

At White Sands there's one troublesome problem with DOVAP; the doubled frequency from the missile (73.88 mc) falls right in the middle of El Paso's Channel 13 TV station. The interference works to upset the DOVAP data rather than the telecasting. Plans are under way to use a different frequency.

Another system is RDME (Range and Distance Measuring Equipment), developed to make miss calculations. In this system, a telemetry transmitter is put in the missile and an antenna is put in the airborne target which receives the fm signal and then relays it to ground. Phase comparison techniques are then used to calculate miss distance. The big advantage of this system (over ITOR, for instance) is the fact that all data is on the ground, out of harm's way.

A similar system that also uses telemetry techniques is PARAMI (Parson Airborne Miss Indicator).

Phase comparison looks like a good approach for electronic systems right now. It is at the heart of most of the ones currently under study. Other electronic systems:

- AZUSA (named for its place of development, Azusa, Calif.) uses two antennas to determine the phase angle of the missile and two more to determine direction angles. The system has a high degree of accuracy but it is extremely expensive ($1½ million for one station) and is difficult to maintain. Other systems that use a similar principle have been nicknamed PMA (for Poor Man's Azusa).
- One of these is DORAN (which means Doppler Range), a combination of DOVAP and AZUSA.
- Another PMA, called EMA (Electronic Missile Acquisition), is currently being studied at WSPG. Less accurate than the AZUSA system, its purpose is to supply electronic theodolites whose digital readings would be placed immediately on magnetic tape for quick data reduction.
- Still another system is COTAR (Cosine-Trajectory-Angle and Range). The Cubic Corp. is currently refining design of this equipment for production. It is basically an advancement over EMA.
- Finally there's MIRAN (Missile Ranging) a system that uses radar without directional properties. Its biggest application is in the testing of air-to-air missiles. A number of antennas are employed to pick up the signals. However, timed pulses rather than a continuous radar wave make up the output of the transmitter.

Data reduction

With the tremendous flow of data produced at WSPG, Billups has had to set up an unique type of organization to process it. He points out the job is more than just processing data. First, his data-reduction group works with the missile-project engineer to help establish the range instrument plan—what instruments to use, and how to use them. Billups has a section from which he assigns one man as full-time liaison for each missile project. That gives each missile officer at White Sands somebody to keep track of how reports are coming and to answer specific questions about data reduction on his project.

A Measurements Section is set up to handle four types of work: 1) optical, 2) Doppler, 3) telemetry, and 4) maintenance. Another group, the Analysis Group, studies error theory and develops new techniques for handling the data received at White Sands. Still another, the Computing Section, operates the 1103 and will operate the new 1103A (or 704).

The final data-processing section is responsible for preparing the report. This is an important document: actually it's the reason for all the simulation, the range firing and the data reduction. From it, engineers evaluate the missile and its design, military men study its tactical potential, and production men check the quality of current production—all of which are functions of testing at WSPG.

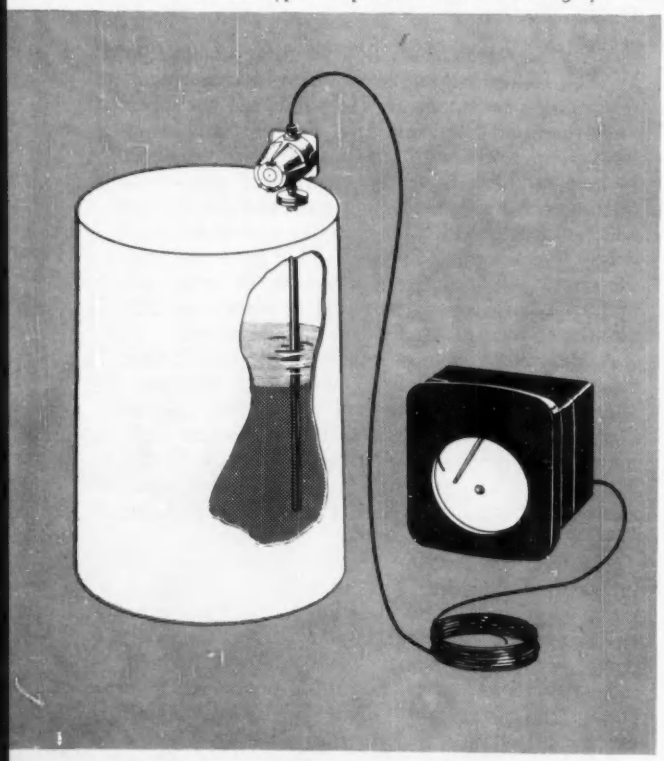
Use Capacitance for Accurate Level Measurement

Systems for measuring the level of a process material range in complexity from simple sight gages to closed-circuit industrial television. Each system has its own area of application, its own advantages and limitations. To be able to select the most appropriate system, the control engineer should be familiar with the underlying principles of each. In the following pages the author presents the basic principles involved in measuring level by the capacitance method. The technique, though simple, requires an engineering analysis of the intended application and an understanding of the capacitance-level correlation.

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(Now employed by Applied Science Corporation of Princeton, Princeton, N. J.)

FIG. 1. Typical capacitance level measuring system.



In many process industries, no variable is more universal than level of a material in a vessel. Whether it is sufficient to know a tank is empty or full, or whether a slight variation in level need be detected, some form of measurement is required.

The technique of using the dielectric properties of either a liquid or granular solid material to measure its level and certain other process variables, is now well-established. Capacitance instrumentation, advancing in design, offers a degree of accuracy previously associated only with laboratory-type equipment, and thus accommodates variables convertible to extremely small changes in capacitance.

Because level measurement is so universal, and its applications so diversified, the control engineer should have some understanding of the fundamentals and limitations of the capacitance method. The strength of this method lies in its simplicity and adaptability. Installations have been notably successful even under extremely adverse conditions.

Basic principles

Figure 1 shows a typical liquid-level installation using the capacitance method. The system consists of two major parts.

The first is an arrangement whereby level variations cause changes in capacitance. In Figure 1, the probe, insulated from the vessel, forms one plate of a capacitor. The vessel itself represents the other, or grounded plate. The space between the two comprises its dielectric. As the level rises, air, with a unity dielectric constant, is replaced by process material which has a higher dielectric constant. The capacitance increases linearly.

The second major part of the installation shown is an instrument, calibrated in units of level, which measures these capacitance changes and positions a pen or pointer accordingly.

This equipment has certain inherent advantages:

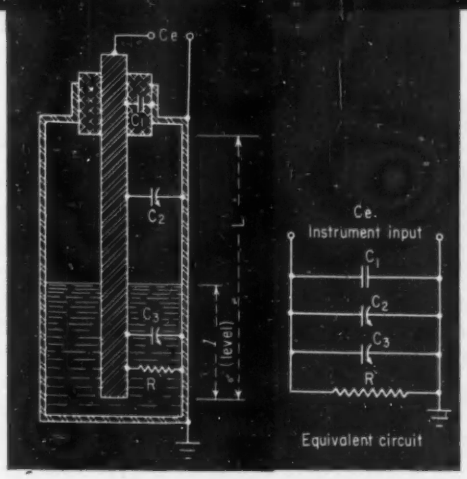


FIG. 2. Level measurement using bare metal probe.

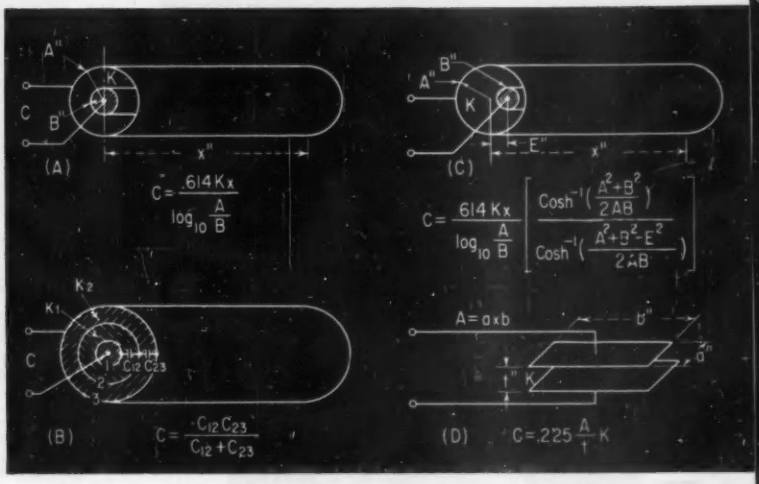


FIG. 3. Basic capacitance formulas for various plate arrangements.

both measuring element and instrument feature simple design; the probe and its insulator can be of a material that will meet stringent process requirements; where application requires measurement in a pressurized vessel, the seal at the insulator can be designed for extremely high temperatures and pressures; where the material measured is highly corrosive or conductive, the probe can be covered over its entire length with a suitable insulator—a Teflon covering, for example; there are no purge requirements, thus eliminating that source of maintenance complication; and the full instrument scale can be made to reflect an extremely small range of level change.

As with any measurement, certain limitations must be recognized. In the main, these can be circumvented by careful analysis of the intended application. Some level problems do not lend themselves to the capacitance method; others are admirably suited.

Bare metal probe

The electrical circuit equivalent to the bare metal probe is shown in Figure 2. This circuit, from which the input to the capacitance measuring instrument is derived, consists of three capacitors in parallel, shunted by a resistance.

C_1, the dead capacitance of the system, includes any capacitance between probe and vessel which does not change as the level in the vessel varies. In part, it is the capacitance at the insulator between the probe and vessel. It also includes the capacitance between the bottom of the probe and the bottom of the vessel, zero being the point where the material is flush with the end of the probe.

C_3 is the capacitance of the system over that length of probe where the dielectric is that of the process material, K_p.

C_2 is the capacitance over the remaining length of the probe, involving a dielectric of air or gas, under pressure or vacuum, K_A.

R is the effective ohmic resistance between the probe and the vessel. It varies with the resistivity of the process material, its dielectric losses, and the level in the vessel. If this resistance is zero, capacitance measurement is impossible with a bare metal probe as a dead short-circuit would exist. For simplicity in the following example, this resistance is assumed infinite.

Figure 3A shows the basic formula for computing capacitance in micromicrofarads for cylindrical capacitors. Applying this formula to determine the capacitance corresponding to any level in Figure 2 leads to:

$$C_e = C_1 + C_2 + C_3 = C_1 + \frac{[0.614\,K_A(L-l)}{\log_{10} A/B} + \frac{0.614\,K_p(l)}{\log_{10} A/B} \qquad (1)$$

Equation 1 shows that, with K_p greater than K_A, a level increase will decrease C_2 while C_3 increases more rapidly, both changes being linear. The net result is a linear increase in total capacitance with increased level. The instrument reflects this capacitance on a scale calibrated in level.

The objective of an application is to make the level term, l, the only variable in Equation 1.

One potential variable is the position of the probe. If the probe moves at any time to an eccentric position, Equation 1, which is based on coaxial geometry, must be modified to conform with Figure 3C. The result is different capacitance for the same level. Properly mounted, the probe will maintain a fixed position and this effect will not occur.

If the dielectric constant, K_A, varies, it will produce an error. Where the dielectric material is a gas, the effect will, of course, be negligible. Consider now the dielectric constant, K_p, of the process material. To compute the instrument range, the

magnitude of K_p must be known, and it must remain sufficiently constant to maintain a capacitance-to-level correlation of required stability. Because the dielectric constant varies with the composition of the material, a change in the constituents will produce a change in dielectric constant.

The dielectric constant of any material varies with temperature. When such variation becomes significant enough, it may be necessary to either control the temperature in the vessel, or allow for the temperature difference when reading the instrument.

Next is the term R. With a bare metal probe, the instrument will not operate when R is zero,

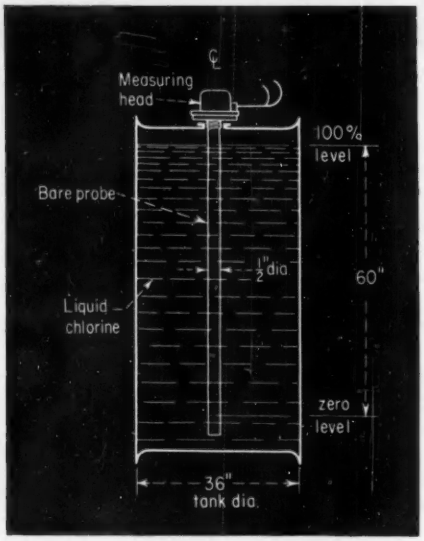


FIG. 4. Tank showing typical dimensions for computing capacitance.

for, as mentioned earlier, a dead short exists. When R is infinite, only the accuracy of the instrument as a capacitance measuring device is significant. For any value of R less than infinity, there will be an effect on measurement. R, of course, varies with most of the conditions affecting K_p.

As a concrete example of how Equation 1 may be used to compute the required instrument range, consider the following hypothetical case. It is necessary to continuously record the level of liquid chlorine in a tank dimensioned as shown in Figure 4. The dielectric constant, K_p, of this material at 14 deg C is 1.91. The zero and 100 percent levels are as indicated in the figure. Assume that the bare metal probe measures 0.5 in. in diam and that the dead capacitance of the system is 15 $\mu\mu$f. When the tank is emptied to the zero level, l in Equation 1 becomes zero. The total capacitance then equals

$$C_e = 15 + \frac{0.614\ (1)\ (60 - 0)}{\log_{10} 36/0.5} + 0 = 34.84\ \mu\mu f$$

Filled to the 100 percent mark, the tank would have a total capacitance of

$$C_e = 15 + 0 + \frac{0.614\ (1.91)\ (60)}{\log_{10} 36/0.5} = 52.82\ \mu\mu f$$

This indicates a required span of approximately 18 $\mu\mu$f. One commercially available unit has a minimum span of 13 $\mu\mu$f, a maximum span of 29 $\mu\mu$f, and a maximum zero elevation of 600 $\mu\mu$f. This would be quite suitable for the application discussed.

Insulated probe

The useful range of capacitance measurement may be extended to high conductivity materials by using an insulated probe as shown in Figure 5. Here, capacitance corresponding to a level l can be equated as follows, R being assumed infinite:

$$C_e = C_1 + \frac{C_2 C_4}{C_2 + C_4} + \frac{C_3 C_5}{C_3 + C_5} \qquad (2)$$

In the case where $R = 0$,

$$C_e = C_1 + \frac{C_2 C_4}{C_2 + C_4} + C_5 \qquad (3)$$

Individual capacitance factors can be obtained by suitable application of Figure 3. This leads to a more detailed equation similar to Equation 1.

However, the significant point here is that the system presents *pure* capacitance to the instrument whether R is zero or infinite. But equations for these two cases are considerably different! Changing a pure resistance changes pure capacitance.

Intermediate values of R will produce complex impedances, but the magnitude of the capacitance term depends on the value of R. Regardless of how completely the instrument ignores the resistive effects of this complex impedance, its pen or pointer will move when R changes.

"Hang-up"

Another factor affecting the measurement of conductive materials is that of "hang-up".

Figure 6 illustrates a condition where material in the vessel rose to a level corresponding to l_1, exhibiting to the instrument a capacitance in accordance with Equation 3. The level subsequently dropped to l_2, leaving the outside of the probe wet. Each incremental length of probe has a capacitance, c, through its dielectric to this wet layer. There capacitances are grounded by the series resistances r.

If r is zero, capacitance presented to the instrument is identical with Equation 3 for $l = l_1$. That is, the instrument pen or pointer does not drop to reflect l_2. If r is infinite and the thickness ignored, the instrument records level l_2. Intermediate values of r produce intermediate scale values.

The value of r depends on the resistivity of the process fluid, the thickness of the film, and the material and finish of the probe covering. A particular point is made of the latter because a material

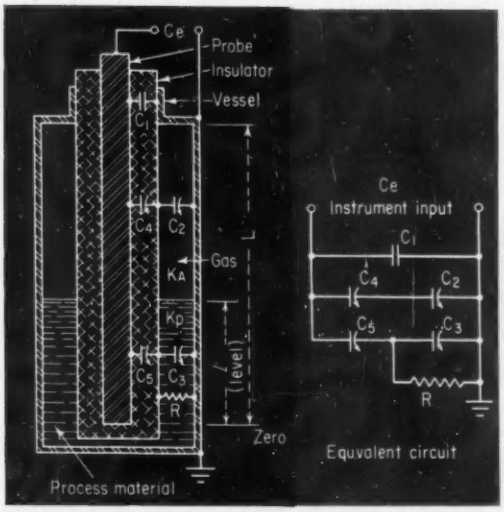


FIG. 5. Insulated probe permits measurement in conductive fluids.

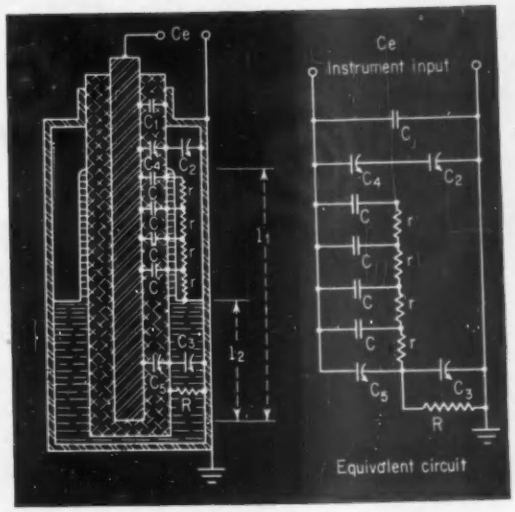


FIG. 6. "Hang-up" of material on the probe affects reading accuracy.

and finish may be chosen to which the process material will not adhere.

Here are some of the questions which should be answered in connection with "hang-up": Will the process material adhere to the probe insulation? Are there probe materials to which it won't adhere, or can the insulation be skin-coated with something to prevent it—Halowax, for example? If the material adheres, how thick is the film, and will it accumulate with time? What is the resistance of the film? Does it remain wet and conductive or dry out and become nonconductive? If it dries, does it dry fast enough to produce adequate measurement response?

Frequency effects

Capacitance measuring instruments usually operate with alternating current at a particular frequency. The characteristics of resistance-capacitance circuits (Figures 2, 5, and 6) change radically with the frequency of the applied voltage. These effects are basic, and should be considered.

Capacitive reactances, in ohm, vary inversely with frequency—the higher the frequency, the smaller the reactance. However, resistances in ohms remain relatively constant. If they vary at all, they increase because of skin effect.

In Figures 2, 5, and 6, assuming a given resistance, *R*, the circuit becomes increasingly capacitive as the frequency is increased. Given percentage variations in resistance (varying conductivity) have diminishing effects because these resistances are more nearly short-circuited by capacitive reactance.

As the frequency increases, even "hang-up" is affected (Figure 6). All capacitive reactances decrease. The resistances, *r*, remaining constant or increasing, can no longer as effectively couple the capacitances, *c*, to ground. Their effect is now blocked and the "hang-up" condition alleviated.

Other factors being equal, it becomes obvious that high, i.e., radio-frequency operation offers definite advantages in the measurement of level.

Applications

Continuous level measurement by the capacitance method involves an electronically operated instrument. In terms of instrumentation cost, therefore, it is generally more expensive than mechanical or pneumatic devices. On the other hand, it is usually more economical than level-measuring devices using radio-active isotopes.

Because of this cost factor, its use rests in those applications where, for one reason or another, lower-priced devices are inadequate. Typical examples of capacitance applications are:

- continuous level measurement of powdered or granular bulk solids in vessels, e.g., grain, cement, and dry chemicals.
- cases where the process material is under unusually high or low temperatures, e.g., molten sodium or liquefied gases.
- cases where the process material is corrosive and hard to handle, e.g., liquid chlorine and hydrofluoric acid.
- materials under unusually high pressures, e.g., polyethylene and other plastics.

These are in addition to the many applications for which the less expensive devices must be ruled out on the basis of accuracy alone.

In evaluating an application, the characteristics of the measured material must be established; its conductivity and its dielectric constant together with expected variations. Where conducting material is involved, an insulated probe is a must. For non-conducting materials, such as kerosene, gasoline, and polyethylene, a bare probe is suitable. The problem is distinguishing between the two. Generally it is best to consider materials with conductivities greater than 0.1 micromho per cc as conductive. On doubtful cases, a covered probe should always be specified.

Sensing Nulls with Dual-Range Compression Circuits

A unique compression circuit converts a single-range meter or null indicator into a dual-sensitivity device. Features include automatic switchover from high to low range as signal magnitude changes, and an infinite choice of sensitivity ratios. Both hard-tube and transistor versions are described.

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Pratt & Whitney Co., Inc.

One of the most frequently recurring problems in industrial control work is null detection—where some means must be devised to indicate when two parts of a system are in balance and little or no current flows between them. The system may be as complicated as an extensive bridge network or as simple as two pickup coils connected in series opposition. The null detector may be a meter or some type of sensing device designed to initiate a control action. In all cases, however, the performance of the system depends on how precisely the null can be "read".

It is especially beneficial if the sensitivity of the detector can be increased as the null is approached—a condition that suggests the use of dual-range detection. The coarse or high range would provide sufficient resolution for monitoring the larger currents associated with wide unbalance. Near the null point the fine or low-range detector would take over to afford the sensitivity needed to accurately track the current to zero.

One example of the part played by null detection in industrial control is the Pratt & Whitney point-to-point positioning system for machine tools. The basis of measurement is a precisely machined serrated bar and the control must be able to locate the exact center of any one of the serrations on this bar. The transducer employed for this purpose consists of two balanced coils that make up two legs of an external bridge circuit. A null detector is incorporated in the control to determine when the bridge is balanced, meaning that the transducer coils are exactly centered over a serration.

It is desirable to have very high meter sensitivity for minute displacements of the transducer from the null point and low sensitivity for large displacements so that both can be observed on a single scale. A further aim is to provide automatic switching between the two levels of sensitivity to make null detection fast, as well as accurate. The ratio between the sensitivity levels should be made adjustable to suit the particular installation. The detailed specifications for the positioning control application are:

1. Sensitivity such that a 0.0025 in. displacement from true null point of a magnetic head causes half-scale deflection of a meter. With a total of 50 scale divisions, the sensitivity of this range would be 0.0001 in. per scale division.
2. Full-scale meter deflection only when the head is delivering maximum signal corresponding to maximum bridge unbalance. With the head used, this occurs at a displacement of 0.25 in. from true null. Assuming a linear relationship between displacement and head output, a sensitivity ratio of 100:1 is needed between the lower and upper halves of the meter scale.

Circuit description

The compression circuit developed to achieve such high-performance null detection is shown in Figure 1. The utility of the circuit stems from its ability to amplify minimum values of current while compressing or reducing maximum currents by as large a factor as wanted.

With no signal applied between terminal 1 and ground, the grid of V_1 and V_2 (two halves of a 6SL7 vacuum tube) are essentially at zero bias and both triodes conduct equal currents. This conduction establishes a certain potential from point 2 to ground. With the arm of potentiometer P_4 set to the same potential, the meter current is zero. When a dc input signal—negative with respect to ground—is present and is of such magnitude that both V_1 and V_2 are cut off, the potential at point 2 rises to a new value. Potentiometer P_3 is adjusted so that this new value causes full-scale meter deflection. With a 150-volt supply for the 6SL7 triodes, cutoff occurs at about −2.5 volts.

If a scale sensitivity ratio of 10:1 is desired, P_1 is

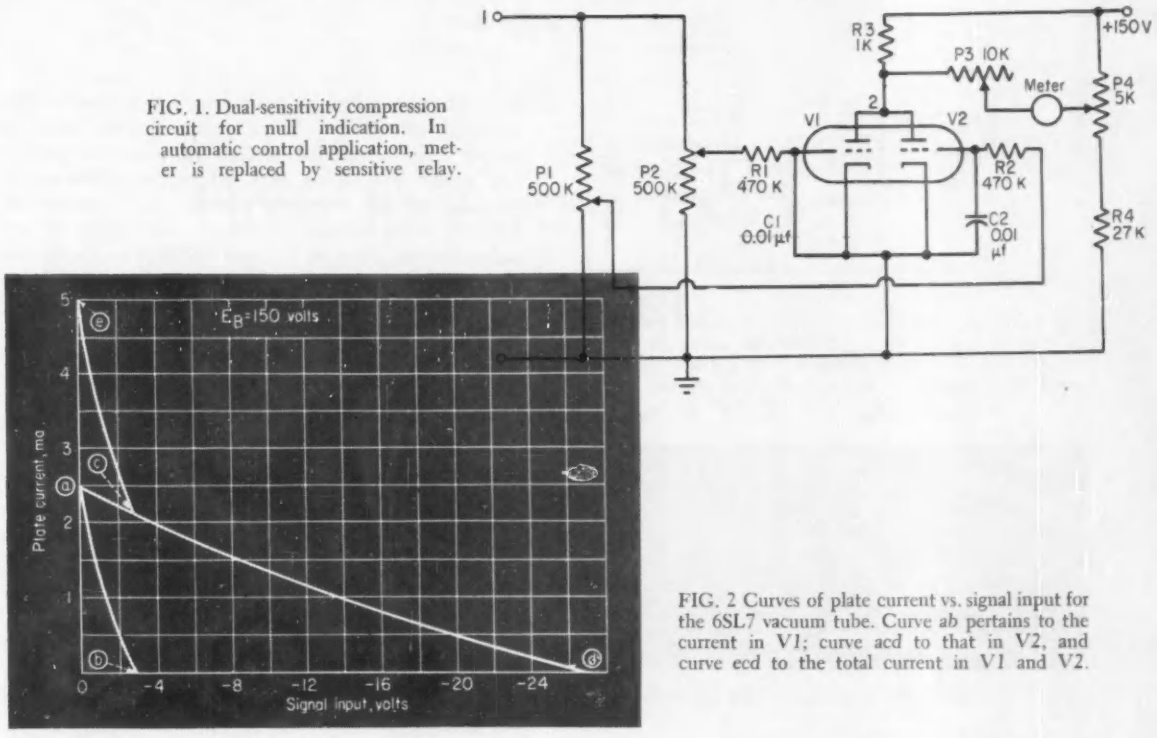


FIG. 1. Dual-sensitivity compression circuit for null indication. In automatic control application, meter is replaced by sensitive relay.

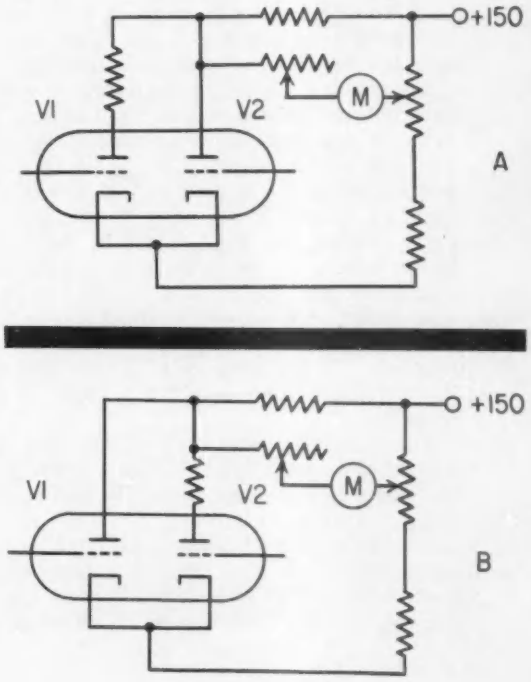
FIG. 2 Curves of plate current vs. signal input for the 6SL7 vacuum tube. Curve *ab* pertains to the current in V1; curve *acd* to that in V2, and curve *ecd* to the total current in V1 and V2.

set for 10 percent of the input signal, while P_2 is adjusted to pass full signal voltage. As the signal rises from zero, conduction through triode V_1 decreases rapidly, reaching complete cutoff at an input of —2.5 volts. At this point, the grid of triode V_2 receiving only 10 percent of signal amplitude is at —0.25 volts so that its conduction is not significantly affected. The potential at point 2 is then approximately halfway up to the maximum possible swing and, therefore, the meter is deflecting half-scale. As the signal amplitude continues to increase, conduction through V_2 is gradually reduced, reaching complete cutoff at —25 volts input for the conditions chosen previously. Now, the meter is deflected to full-scale reading. Further increase of input signal will not result in meter overdeflection. Should it be desired to read the maximum signal encountered, P_1 is simply set for full-scale deflection at this maximum level.

Figure 2 is a graphical presentation of the relationships between the plate currents of V_1 and V_2 and the input signal for the sensitivity settings chosen above. Curves *ab* and *acd* depict the plate currents of V_1 and V_2 respectively. Curve *ecd* shows the sum of these two currents which flows through the common load resistor *R*3. The voltage at point 2 is, of course, directly proportional to the current represented by curve *ecd*.

It is obvious that, with this arrangement, it is possible to get any sensitivity ratio between the lower and upper halves of the meter scale range by adjusting P_1 and P_2 for the desired ratio. The maximum sensitivity is limited by the cutoff voltage required

FIG. 3 Circuit modifications needed to change portion of meter scale allotted to high-sensitivity range. A—Resistance in plate circuits of V_1 limits pointer deflection during high-sensitivity stage to less than half-scale. B—Resistance in plate circuit of V_2 allows pointer to deflect more than half-scale for sensitive indication.



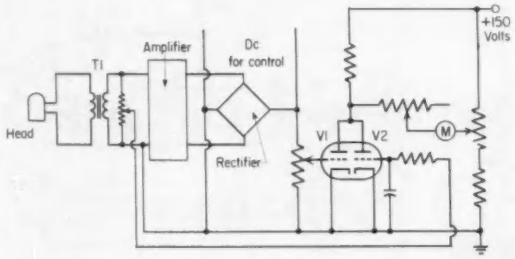


Fig. 4 Circuit combination permitting the reading of 0 to 10 volts on a single scale, with half-scale deflection occurring at 100 millivolt input. Metering circuit is so flexible that ac input is applied to one and dc input to the other.

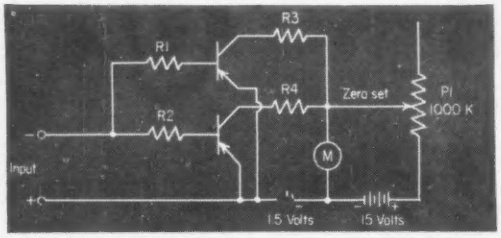


FIG. 5 Transistorized dual-sensitivity null indicator.

for V_1 and V_2. Hence, additional amplifying means must be inserted between the signal source and the input to either P_1, P_2 or both, when the signals to be measured are below the cutoff level of V_1 and V_2.

If it is desired to limit the sensitive portion of the scale range to less than half-scale, a suitable resistor should be inserted in the plate circuit of V_1, as shown in Figure 3. A suitable value of resistance in the plate circuit of V_2 has a similar effect on the less sensitive half of the scale range. In either case, new settings of potentiometers P_3 and P_4 are required for zero and full-scale deflections respectively.

The circuit of Figure 1 is not restricted to dc input only, but may be used with ac input as well. In this mode of operation, the grid resistors *R1* and *R2* limit the grid current to a negligible value on the positive half of the ac cycle so that both triode currents are essentially the same as with zero signal input. During the negative half of the cycle, the triodes behave very much the same as with dc input, except that the average plate current will be somewhat higher. Actually direct current may be fed into one triode grid and alternating current to the other if necessary. If dc input is used, the grid-current-limiting resistors and capacitors *C1* and C2 are not required.

The arrangement used as a solution to the problem mentioned earlier is shown in Figure 4. Output from the magnetic head after step-up by transformer *T1* is approximately 50 millivolts per 0.001 in. of displacement from null point. Maximum output of approximately 12 volts occurs at a displacement of about 0.25 in. This ac voltage is applied directly to one pair of input terminals of the metering circuit and also to an amplifier having sufficient gain for the required sensitivity. Since this amplifier was to supply a dc output for control purposes, the amplified signal is rectified and fed to the other input terminal of the metering circuit. As a matter of interest, it was possible to obtain a sensitivity of one scale division (out of 50) per 0.00005 in. head displacement at the zero end of the scale range while, at the same time, no more than full-scale deflection occurred at the maximum displacement. The circuit constants given in Figure 1 were used with a 0-500 microamp range ammeter having an internal resistance of approximately 60 ohms.

Transistorized version

An experimental grounded emitter transistor circuit was tried using the same meter and a pair of General Electric 2N145 transistors. The circuit is shown in Figure 5. Since the transistors are at cutoff conditions, with no bias current, the current action here is the reverse of that of the tube circuit. With zero signal input, the collector currents are very low. Collector currents increase with signal, their ratio being determined by the ratio of *R1* and *R2*. Maximum collector currents are limited by resistors *R3* and *R4* and the supply voltage. Neglecting the meter resistance and the saturation voltage of the transistors, the values of *R3* and *R4* may be determined by:

$$R3 = \frac{E}{kI_m}$$

$$R4 = \frac{E}{(1-k)I_m}$$

where k = percentage of total scale length to be used for the high sensitivity range, expressed as a decimal.

I_m = full-scale current of meter

E = collector supply voltage

If the high sensitivity range is to take up half of the total scale length:

$$R1 = R2 = \frac{E}{0.5I_m}$$

With *R1* = 10 kilohms and R2 = 1 megohm in the circuit of Figure 4, half-scale meter deflection occurs with 0.3 volt dc input, while −30 volts input is required for full-scale deflection. Higher or lower sensitivities may be obtained by decreasing or increasing the values of *R1* and R2, keeping in mind the fact that the input resistance will be affected and should be considered from the point of view of signal-source loading.

While these circuits were developed with metering as a specific problem, they have possibilities in control applications where special nonlinear characteristics are desired. Curve C of Figure 2 can be altered at will by altering the relative gains of V1 and V2.

Acknowledgment

The author wishes to acknowledge the assistance of Edward E. Kirkham, project engineer of Pratt & Whitney, in the development of these circuits.

How to Avoid Extra Integrators when Simulating RLC Networks

JOSEPH OTTERMAN University of Michigan

THE GIST: Analyzing an electrical or mechanical network by conventional methods often results in equations which require more integrators in an analog computer simulation than the number of energy-storing elements in the network. These additional integrators can cause stability problems and wrong computer solutions.

This article presents a method of loop analysis that yields a computer setup without superfluous integrators. And the number of amplifiers can be minimized at the same time. All voltages and currents (forces and velocities, pressures and flows, etc.) may not be directly available, as in the method of direct simulation[1], but the parameters of interest can usually be observed if only one loop is traced through the element involved.

•

When loop or node analysis is used for writing down the simultaneous differential equations of an electrical network or of a mechanical system and an analog computer is set up to solve the equations, it is quite often found that the number of integrators exceeds the order of the differential equation describing the network or the system. A setup with such excess integrators not only involves more labor and equipment, but can give erroneous results because, if the integrators are not perfectly matched, an extraneous root can be introduced in the characteristic equation.

The computer analog of a simple RLC network can be obtained easily and excess integrators can be avoided by using the direct simulation approach developed by Larrowe[1]. This approach becomes more difficult for complicated networks, especially if the network contains a junction of three or more energy-storing elements of the same kind.

The difficulty of the excess integrators can be eliminated in the loop analysis approach if the currents I_k in the loops are chosen so that the number of terms pLI_k and SI_k/p—where L is a circuit inductance or sum of inductances, S is a circuit elastance (inverse of a capacitance) or sum of elastances, and p the differentiation operator—is kept at a minimum. Node analysis calls for a minimum number of terms with pV_k and V_k/p. This minimum is equal to the order of the differential equation describing the network, i.e., to the number of "independent" energy-storing elements (capacitances and inductances) of the network. In an independent inductance, the current is not determined solely on the basis of Kirchoff's law of currents in terms of currents that pass through other inductances, and the voltage is not determined solely in terms of voltages across other inductances on the basis of Kirchoff's law of voltages. A definition of an independent capacitance is obtained by reading "capacitance" instead of "inductance" in the previous sentence. In a group of interdependent inductances or capacitances, the

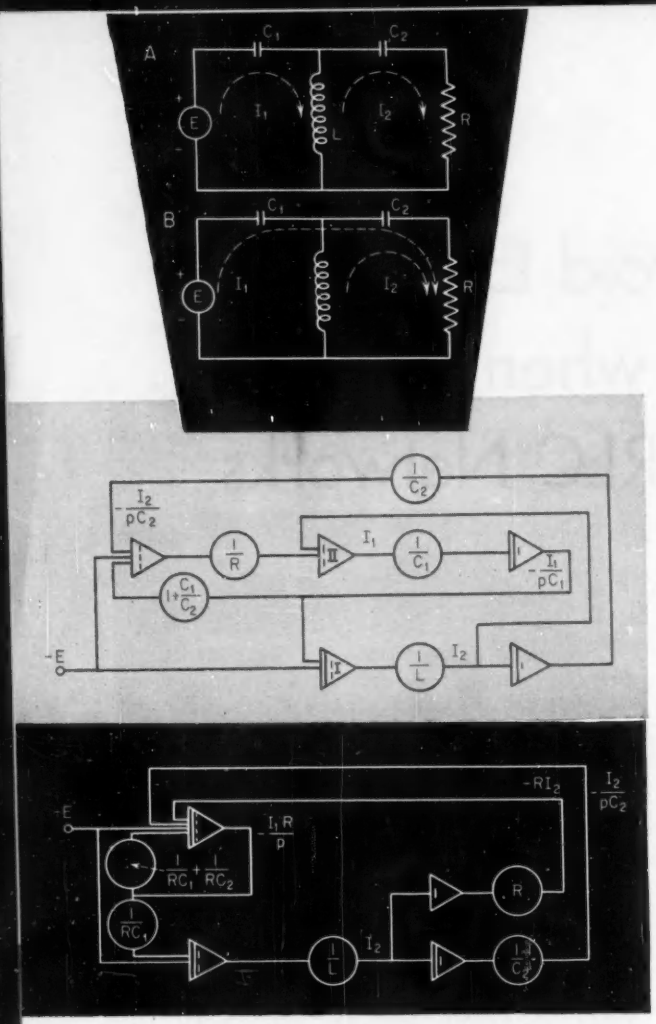


FIG. 1. Tracing loop currents: A—computer setup requires four integrators for three energy-storing elements; B—requires only three integrators

FIG. 2. Computer diagram for solution of Figure 1B.

FIG. 3. Minimum amplifier setup for Figure 1B.

choice of the dependent element becomes arbitrary.

Loop analysis

The procedure for tracing loop currents can best be understood from simple examples. Consider the circuit of Figure 1. When the currents are chosen as in Figure 1A, the circuit equations contain four terms: pLI_1, I_1/pC_1, pLI_2, and I_2/pC_2. These terms appear regardless of what paths are chosen in writing down the equations for voltages in closed loops according to Kirchoff's second law. The simulation requires therefore four integrators, whereas there are only three energy-storing elements in the circuit.

Tracing the loop currents in such a way that only one loop current passes through the inductance L (Figure 1B) eliminates the danger of superfluous integrators. In writing down the equations that stem from Kirchoff's second law we do not necessarily follow the loops traced by the currents:

$$E = \frac{1}{pC_1} \cdot I_1 - pL \cdot I_2 \qquad (1)$$

$$E = \left(\frac{1}{pC_1} + \frac{1}{pC_2} + R\right) \cdot I_1 + \left(\frac{1}{pC_2} + R\right) \cdot I_2 \qquad (2)$$

The equations are solved in a straightforward manner. The computer setup is shown in Figure 2. The terms for $-pLI_2 = E - (I_1/pC_1)$ are summed up by an integrator (amplifier I), and the terms

$$-I_1 = \frac{1}{R}\left[-E + (1/pC_1 + 1/pC_2)\, I_1 + (1/pC_2 + R)I_2\right]$$

are summed up by an adding amplifier (amplifier II). Only three integrators are necessary.

Equations 1 and 2 can actually be solved by a computer setup with one amplifier less, as shown in Figure 3, if the terms for I_1R are summed up directly by an integrator. This setup does not possess, however, the direct analog of the current I_1.

The simulation of a circuit with a junction of three or more energy-storing elements of the same kind does not present any special complication. Consider, for example, the circuit of Figure 4. Four integrators would be required if the currents were traced as in Figure 4A. When only one current is traced through the inductance L as shown in Figure 4B, the simulation can be done with only three integrators. This is the number of independent energy-storing elements in the circuit, since one of the capacitors, say C_3, is not independent, the currents through it being equal to the sum of the currents through the other two. The paths for writing down the equations of Kirchoff's second law are chosen in such a way that the terms with the highest power of p for each current (pLI_1 and RI_2) appear only once in each equation. This choice leads directly to the minimum-amplifier setup:

$$E = \frac{1}{pC_1} \cdot I_1 + \left(\frac{1}{pC_1} + \frac{1}{pC_2} + R\right) I_2 \qquad (3)$$

$$E = \left(\frac{1}{pC_1} + \frac{1}{pC_2} + pL\right) I_1 + \frac{1}{pC_1} \cdot I_2 \qquad (4)$$

The computer setup, with only four amplifiers, is shown in Figure 5. Unlike direct simulation, there is no need for a high-gain amplifier. It should be pointed out that neither the current nor the voltage across the capacitor C_1 is directly available.

The general rule

The two circuits above illustrate application of a general rule (which applies in the same way to capacitances as to inductances), as follows:

In choosing the paths of the loop currents, independent inductances are "assigned" to the currents. The first independent "unassigned" inductance encountered in tracing the curernt I_k is assigned to I_k. The tracing of the current I_k can be continued through any number of dependent inductances, independent unassigned inductances and independent inductances already assigned to other currents. A current cannot be traced through

a dependent or a previously "assigned" inductance unless it has its own assigned inductance.

An exception occurs in the case of a loop consisting of inductances only. In this case a current is traced through the inductive loop resulting (after division by p) in an algebraic equation.

The rule works well and can be applied to the loop analysis of any network. In the case of the network in Figure 4, capacitance C_1 and inductance L are assigned to the current I_1, which passes too through the capacitance C_3. I_2 cannot be traced through L since this inductance has already been assigned and there is no other inductance in the circuit that could be assigned to I_2. Therefore I_2 is traced as in Figure 4B, with C_2 being assigned to it.

The rule does not indicate, however, how to avoid choosing certain current paths which would make it impossible to complete the tracing of the currents through the rest of the network without violating the rule. As an example, consider the circuit and the current paths indicated in Figure 6A. L_1 and C are assigned to I_1, L_2 is assigned to I_2, but any loop current traced through R_3 would violate the rule. A correct solution is indicated in Figure 6B. A more complicated example is presented in Figure 7. Pitfalls such as shown in Figures 6A and 7A will be avoided if *any loop that has an inductance (capacitance) assigned to it is completed, if possible, without a capacitance (inductance) assigned to it.*

In terms of the circuit matrix, the procedure developed here means that unknowns are chosen in such a way that the degree in p (the sum of the exponents of the highest power of p and the highest power of $1/p$) of the product of the matrix diagonal terms is equal to the degree in p of the determinant. The danger of the superfluous integrators arises when the product of the matrix diagonal terms contains some

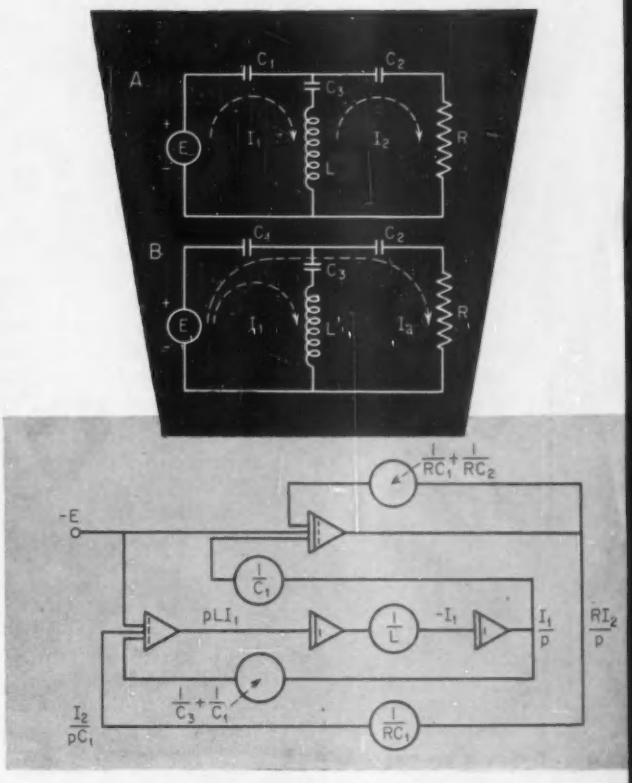


FIG. 4. For junction of three like energy-storing elements: A—requires four integrators for only three "independent" energy-storing elements (see text); B—requires only three integrators.

FIG. 5. Minimum amplifier, minimum integrator setup for network of Figure 4.

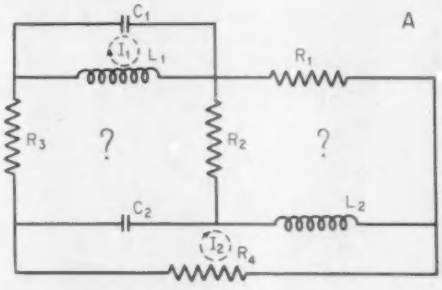


FIG. 7. A more complicated network: A—false start; B—correct solution (others are possible—try them).

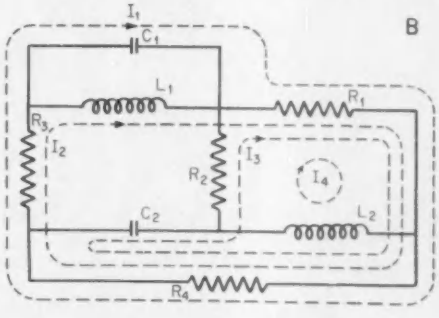
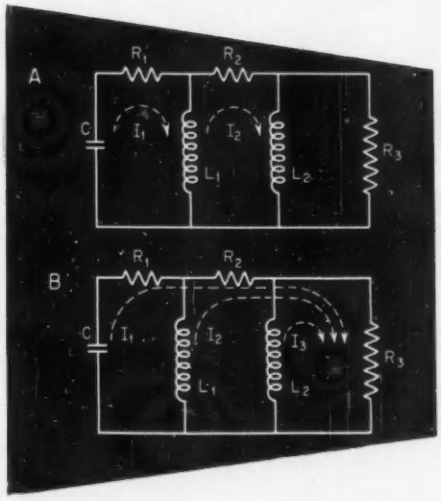


FIG. 6. Illustration of loop-tracing rule: A—false start; B—correct.



higher-power terms, which actually cancel out in developing the determinant.

Node analysis

If the node analysis approach is used to find the computer analog of the network it is impossible, in general, to avoid excess integrators when the voltage variables are chosen in the customary way as voltage drops between the independent nodes and a single reference node. An exception occurs (that is, excess integrators can be avoided even when using the customary form of node analysis) only in the case of a certain type of RLC network, which can be called an L-C-continuous network, in which

a. All the capacitances are interconnected, series or parallel (i.e., no inductances or resistances are interposed), *and*

b. All the inductances are interconnected, series or parallel (no capacitances or resistances are interposed), *and*

c. If both capacitances and inductances appear, there is at least one node common to a capacitance and an inductance.

In the analysis, such a node adjoining both a capacitance and an inductance has to be chosen as the reference node; in a network with only capacitances (only inductances) and resistances, any node adjoining a capacitance (an inductance) and a resistance can be taken as the reference node. It should be pointed out that changing the order of the elements in a series connection might sometimes make an L-C-continuous network out of a network that does not have the required properties and vice-versa.

Examination of Figures 1, 4, and 6 reveals that all of these networks belong to the L-C-continuous type, whereas the network of Figure 7 does not.

For an example of node analysis, consider the network of Figure 4, which is presented again in Figure 8 with the reference node indicated at a junction of a capacitance and an inductance. In Figure 8B the voltage source has been replaced by a current source. The node equations are:

$$I = EpC_1 = (pC_1 + pC_2 + pC_3)\,V_1 - pC_2\,V_2 - pC_3\,V_3 \quad (5)$$

$$0 = -pC_2\,V_1 + \left(pC_2 + \frac{1}{R}\right)V_2 - 0 \quad (6)$$

$$0 = -pC_3\,V_1 + 0 + \left(pC_3 + \frac{1}{pL}\right)V_3 \quad (7)$$

After division p, we obtain:

$$EC_1 = (C_1 + C_2 + C_3)\,V_1 - C_2\,V_2 - C_3\,V_3 \quad (8)$$

$$0 = -C_2\,V_1 + \left(C_2 + \frac{1}{pR}\right)V_2 + 0 \quad (9)$$

$$0 = -C_3\,V_1 + 0 + \left(C_3 + \frac{1}{p^2L}\right)V_3 \quad (10)$$

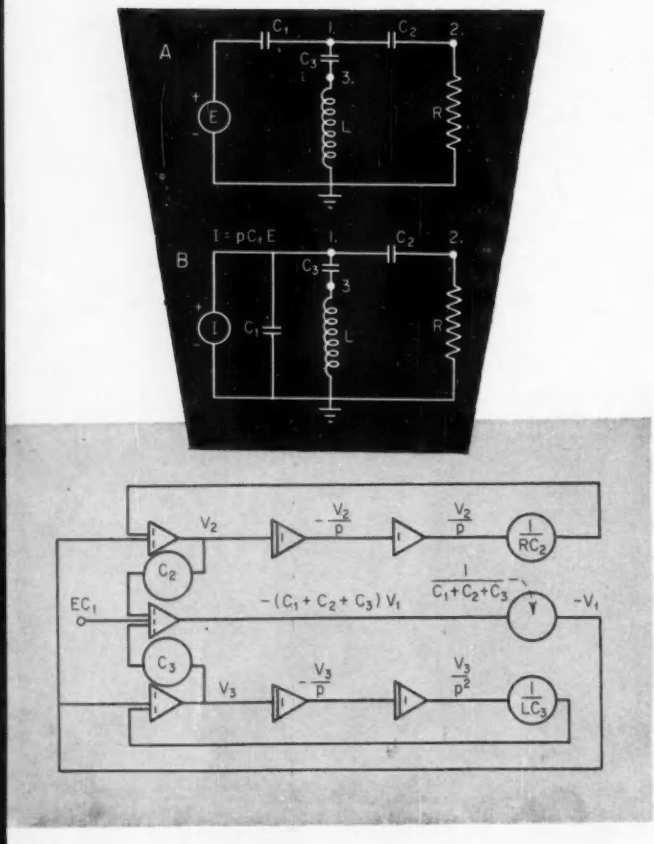
The corresponding computer setup is shown in Figure 9. Seven amplifiers are used. Only four are required for loop analysis, Figure 5.

Excess integrators can be avoided even if the node analysis is extended to networks which do not belong to the L-C-continuous type. In these cases, however, superposition of voltages has to be used. This concept is dual to the superposition of several loop currents through the same element.

It appears that the method of direct simulation is to be recommended for simple networks. For complicated networks, especially networks involving junctions of several inductances or several capacitances, the outlined loop analysis is best suited. Node analysis can be very useful when the availability of voltages at all the nodes is advantageous, and for networks with fewer nodes than loops.

FIG. 8. Illustration of node analysis of circuit of Figure 4.

FIG. 9. Node analysis yields computer circuit with seven amplifiers as compared to four for loop analysis, Figure 5.



The preceding was noted by the writer while engaged in the computer investigation of certain electrical networks[2] for the University of Michigan Engineering Research Institute, Project No. 2370-2, sponsored by the Chrysler Corp. The writer is indebted to Fred L. Bartman, Elmer G. Gilbert, and especially Edward O. Gilbert for useful comments.

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CALCULATE GYROSCOPE PRECESSION TORQUES

A. E. MAINE, De Havilland Aircraft of Canada, Ltd.

A torque acting on one gymbal of a gyroscope causes the gyro to rotate (precess) about an axis in quadrature to the direction of the torque and at a rate proportional to the magnitude of the torque. Two types of precession concern engineers responsible for the application of gyros and gyro equipment:

- precession deliberately introduced to move the gyro axis through some prescribed path
- an unintentional, slow precession known as "wander rate", caused largely by friction in the gymbal bearings

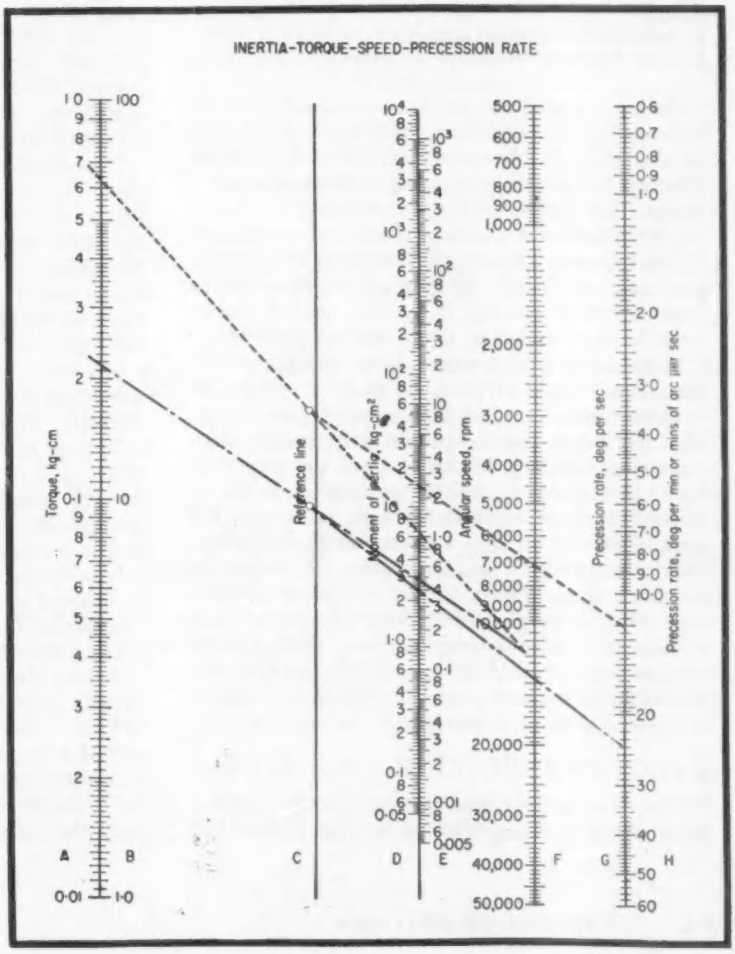
To choose the appropriate torque motor out of the variety of electric and pneumatic ones available for producing the deliberate precession, the control engineer must determine the magnitudes of torques:

- necessary for desired deliberate precession
- caused by the "wander rate" precession

He can determine both with the nomograph below. In typical ranges, the nomograph solves:

$$T = I\,\omega\,\Omega$$

Where T is torque (applied or developed), dyne-cms
I is moment of inertia of rotating parts, g-cm²
ω is speed of rotating parts, radians per sec
Ω is precession rate, radians per sec



Two examples demonstrate the use of the nomograph.

EXAMPLE 1

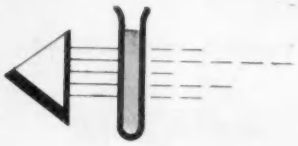
A gyroscope wheel rotates at 12,000 rpm, the rotating parts having a moment of inertia of 2.5 kg-cm². Find the torque required to precess the gyroscope at a rate of 12 deg per sec.

The required precession rate, 12 deg per sec, is located on scale (*G*) and the moment of inertia on scale (*E*). A rule laid across the chart to connect these points intersects reference line (*C*). From this intersection the rule is repositioned to join 12,000 on the rpm scale (*F*) and the answer is read from where the ruler strikes scale (A), i.e., $T = 670$ g-cm

EXAMPLE 2

The same gyroscope has a wander rate of 24 deg/min. Find the equivalent torque reaction.

The nomogram is used in the same way, but now the second set of precession and moment of inertia scales is applied. Set the rule at 24 on scale (*H*) and 2.5 on (*D*) and note the intersection with the reference line. From this point set the rule to connect with 12,000 on the rpm scale. Read the answer, 22 g-cm, from the intersection with scale (*B*).



INFRARED PROCESS-STREAM ANALYZERS

Last month Leo Glasser reviewed the class of composition-measuring instruments known as photometric stream analyzers and then covered the details of one of them: the ultraviolet analyzer. This month, Dan Troy continues the discussion of photometric techniques by considering a related instrument, the infrared process-stream analyzer.

In the past ten years the number of infrared analyzers in plant service in the chemical and petroleum industries has increased from a negligible amount to more than a thousand, making this instrument the most widely used composition-measuring device today and an established article of commerce (at least five instrument companies manufacture it).

Generally, manufacturers have a broad background of application experience and can advise prospective users on the performance to be expected from their equipment in specific circumstances. However, some informed judgment by the user about infrared stream analyzers is often necessary to select the best device for a particular application.

DANIEL J. TROY
Engineering Research Laboratory
E. I. du Pont de Nemours & Co., Inc.

An infrared analyzer, which continuously measures process-stream composition, operates by responding to the stream's absorption of infrared radiation. Among composition-measuring instruments, it is outstanding for its ability to respond to a great variety of substances (all chemical compounds) and (unambiguously) to a specific substance in a complex mixture. While its greatest use has been in gaseous process streams, it has had marked success recently in a number of liquid analysis problems.

In sensitivity of detection infrared occupies a middle ground: while substantially more sensitive than most instruments measuring physical properties (e.g., refractive index, thermal conductivity, specific gravity, sound velocity), it cannot equal the sensitivity of ultraviolet or electrolytic analyzers. With an infrared analyzer adapted for high sensitivity, 0.4 ppm of carbon dioxide, a strong infrared absorber, can be detected in simple mixtures. As far as its selectivity is concerned, it can measure 0–50 percent ethylene to plus and minus 0.5 percent in a varying mixture containing methane, ethane, acetylene, propane, ethyl chloride and hydrogen chloride. The table on the next page lists typical applications of infrared to plant stream problems.

BASICS OF INFRARED

The term infrared describes electromagnetic radiation whose wavelength is longer than visible light and shorter than radio waves; that is, wavelengths between 0.7 and 500 microns. Though a number of practical considerations have confined industrial infrared analyzers to wavelengths between 2 and 15μ, within this region many chemical compounds of industrial interest absorb strongly.

The relative usefulness of a spectroscopic instrument (like a musical instrument) is often indicated by the number of octaves in its range. Thus, while the visible spectrum covers less than one octave and the ultraviolet spectrum available to industrial analyzers covers just one octave (0.2 to 0.4μ), the spectrum available to infrared analyzers covers nearly three octaves. One would therefore expect infrared analyzers to be able to detect a greater number of substances and to detect them in more complicated mixtures. This turns out, in fact, to be the case.

Infrared energy is absorbed within the wavelength range of 2 to 15μ because the frequencies of the infrared radiation correspond to characteristic frequencies of vibration of specific molecular bonds in various compounds[2]. For analytical purposes it is only necessary to know that absorption at a particular infrared wavelength results from the presence of a particular (or class of) chemical compound.

The infrared spectrum of a compound, Figure 1, will show absorption at a number of different wavelengths, corresponding to different portions of the molecule. Moreover, each absorption occurs not only at a single specific wavelength, but also occurs at adjacent wavelengths, so that the spectrum exhibits "absorption bands". Notice in Figure 1, however, that while the absorption bands are spread

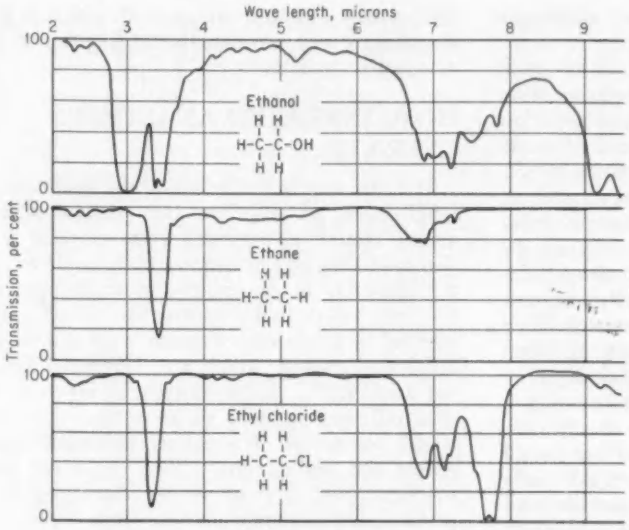


FIG. 1. Infrared spectra of ethanol, ethane, and ethyl chloride typify the fact that each compound has a unique pattern which aids in selecting wavelengths giving best sensitivity and selectivity.

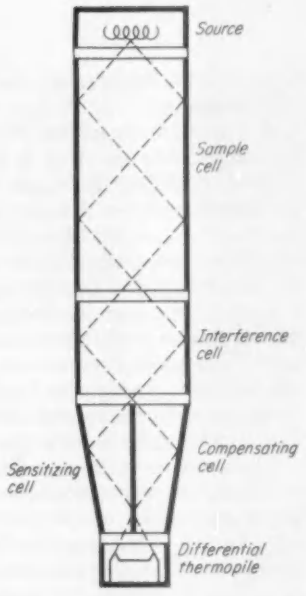


FIG. 2. Optical system of a nondispersive infrared analyzer with nonselective detector.

out over a range of wavelengths, each band occupies only a small portion of the infrared spectrum.

Usually a compound to be detected in the presence of others in a mixture will exhibit one or more unique absorption bands. An analyzer responding selectively to the wavelengths of these unique bands measures the concentration of the compound. When the absorption bands of different compounds do overlap, the overlapping region is only a fraction of the total bandwidth. This relative narrowness of infrared absorption bands is one of the reasons why infrared analyzers are so versatile.

The basic elements for an infrared analysis are:

- a source of infrared radiation of suitable analytical wavelengths; that is, wavelengths that are strongly absorbed by the substance to be determined and not significantly absorbed by other substances.
- a detector sensitive to infrared radiation.
- a sample cell, having infrared-transparent windows and located between the source and the detector, through which the sample passes.

These requirements are easy to state but difficult to satisfy. That they have been met by instruments already in wide use is a tribute to the ingenuity of the scientists and inventors who have been working on this problem for the past 10 to 20 years.

SOME PLANT-STREAM APPLICATIONS OF INFRARED ANALYZERS

Analysis for:

- purity of ethylene in ranges of 90-100 percent
- purity of butadiene in ranges of 95-100 percent
- methane and ethane in ethylene
- carbon dioxide in hydrocarbon streams
- carbon dioxide in furnace atmosphere
- carbon dioxide and carbon monoxide in combustion control
- carbon dioxide and carbon monoxide in the range of 0-50 ppm in ammonia synthesis gas
- trace water in liquid benzene and Freon
- remaining methane in reforming of natural gas to hydrogen
- phosgene in hydrogen chloride
- alcohol vapor in air-hydrocarbon mixture
- methyl vinyl ketone in butadiene

(*Collected from the literature*)

Radiation source

The radiation source in all infrared analyzers is an incandescent solid, usually a coil of some corrosion-resistant metal heated by passing an electric current through it. Its operating temperature (700 to 1,500 deg K) is much lower than the familiar incandescent lamp (2,800 to 3,000 deg K). Lower temperature reduces infrared radiation but reduces unwanted visible radiation even more, and prolongs life indefinitely. The wavelength distribution of the infrared energy from this source follows Planck's Radiation Law. Sixty to 95 percent of the radiation is in the wavelength range 2 to 15μ. Since this radiation source does not selectively radiate the desired analytical wavelength, a fourth basic element must be added to the analyzer: a wavelength selector.

Radiation detectors

Two types of radiation detectors are in current use in infrared process-stream analyzers: the radia-

tion thermocouple and the gas-filled condenser microphone.

A radiation thermocouple consists of a small blackened plate to which a thermocouple junction is attached. When illuminated by infrared radiation the plate heats to a higher temperature than its surroundings and the thermocouple produces a voltage output proportional to the radiant power striking it. Sometimes the thermocouple is mounted in an evacuated chamber to increase its sensitivity by minimizing convective heat loss. Sometimes a number of thermocouples are connected together to form a thermopile, usually with half the junctions shielded from the radiation or exposed to a reference beam to compensate for ambient temperature changes.

The problem in using radiation thermocouples is to distinguish the temperature changes due to radiant energy from temperature changes due to all other causes. One type of analyzer solves this problem by combining a compensated thermopile with extreme thermostatting and thermal shielding. Another type of analyzer uses periodic interruption of the beam of infrared energy. Here, only the component of the thermocouple output that varies at the interruption frequency is measured.

In the condenser microphone detector a sealed chamber with a window on one side is filled with gas capable of absorbing infrared radiation. This energy absorption heats the gas, causing a pressure rise that deforms a metal diaphragm set in one wall of the chamber. The diaphragm forms one plate of a capacitor whose variation in capacitance provides a measurement of the radiant power.

Again there is the problem of distinguishing pressure changes due to infrared radiation from those due to changes in ambient temperature. Here it is overcome by periodically interrupting the radiation as described above and making the measuring system respond only to capacitance changes occurring at the interruption frequency. By mounting a second chamber on the other side of the diaphragm and placing a small hole in the diaphragm itself, relatively slow changes in pressure due to ambient changes have no effect at all.

The condenser microphone has a special advantage. By properly selecting the gas with which it is filled it can serve as a wavelength-selecting device as well as a radiation detector.

HOW INFRARED ANALYZERS OPERATE

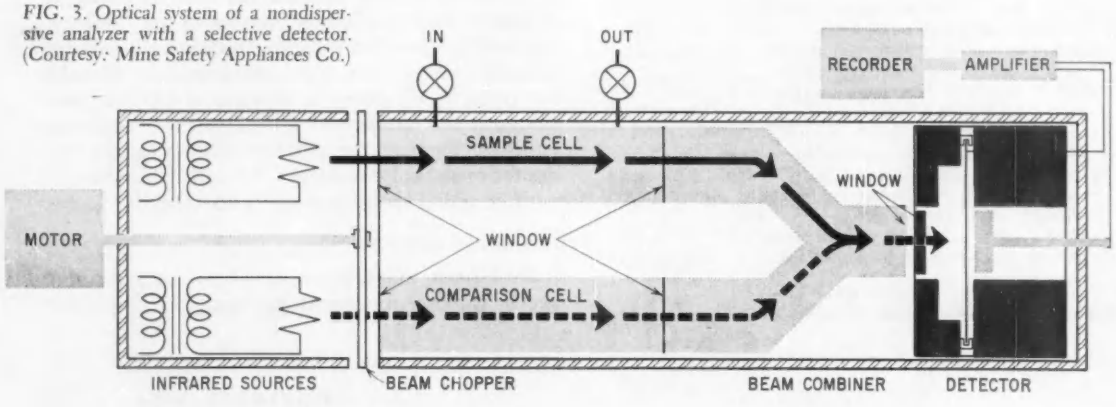
It is the method of selecting the analytical wavelength that accounts for the greatest differences among commercial infrared analyzers, and it is on this basis that an attempt is usually made to classify the analyzers as dispersive and nondispersive. In the first, the desired wavelength or wavelengths are selected by a dispersive element, such as a prism or a diffraction grating, which acts differently on different wavelengths. Each wavelength forms an image at a different location in an optical system, and proper placement of a narrow slit-shaped aperture selects the desired one. Two dispersive infrared analyzers using a prism as the dispersing element are available commercially, one from Perkin-Elmer and the other from Beckman Instruments.

Nondispersive analyzers

Nondispersive analyzers achieve wavelength selection by optical filtering. All available nondispersive analyzers are of a type called self-filtering: a gaseous sample of the component being detected is sealed in a container within the analyzer to serve as a filter. Analyzers of this type are made by Leeds & Northrup, Analytic Systems Co., Beckman, Mine Safety Appliances, and Perkin-Elmer. Nondispersive analyzers fall into two subclasses, those with a nonselective detector responsive to all infrared wavelengths (e.g., a radiation thermocouple) and those with a selective detector (e.g., a condenser microphone filled with a particular infrared-absorbing gas).

In a typical nondispersive analyzer of the nonselective-detector type (see Figure 2) the radiation from an incandescent source travels by different routes to two opposing halves of a radiation thermopile. The output of the thermopile is thus proportional to the difference in radiant power in the two paths. The source emits and the detector responds to all infrared wavelengths. Selectivity is attained

FIG. 3. Optical system of a nondispersive analyzer with a selective detector. (Courtesy: Mine Safety Appliances Co.)



entirely through sealed-cell filters containing gaseous samples of the material being detected and sometimes of other materials present in the stream.

The process stream to be analyzed flows through a sample cell placed in both radiation paths. A sealed cell placed in one radiation path only is filled with a gaseous sample of a component being detected. In this way, all infrared wavelengths absorbed by this component (i.e., all the analytical wavelengths) are removed from this path, and the radiant power in this path is unaffected by changes in concentration of that component in the sample. The radiant power in the other path, however, is affected: it contains all infrared wavelengths, including the analytical wavelengths. The difference in radiant power in the two paths is due to the analytical wavelengths only. The analyzer has thus been "sensitized" to the desired material. In a simple case, this is all that is required. Because of the indirect method of wavelength selection, this type of analyzer has also been given the name "negative-filtering". The use of two radiation paths also partially compensates for unavoidable fluctuations in radiation-source output. The polished inner walls of the cells used to hold the various mixtures direct their radiation by a technique called "barreled optics", which means multiple reflection without the need to form focused images.

In the analysis of complex mixtures containing a number of infrared absorbing materials, the sensitization procedure can become considerably more elaborate. Besides placing the material to be detected in one radiation path, carefully controlled amounts of other ingredients of the process stream may be placed in the other or both paths. The amounts are determined experimentally to provide the maximum response to the desired substance with the minimum response to other ingredients in the mixture. Reference 1 describes the sensitizing process.

This type of infrared analyzer was for a long time the only type available in this country. It has been successful in a wide variety of gas analysis applications, but cannot be used for liquid analysis or for the complicated analytical tasks performed by some of the later and more elaborate instruments. However, it is simple in its optical system, its mechanical construction, and its electronic circuitry. Since this instrument operates by measuring the relatively small difference between the large amounts of infrared energy coming from two radiation paths (with somewhat different energy proportions at various wavelengths), excellent regulation of the infrared source is required. Moreover, the radiation beams are not periodically interrupted, so careful thermostatting and thermal shielding must be used in the analyzer to eliminate changes in the infrared radiation reaching the detector from the walls of the instrument. Leeds & Northrup manufactures an excellent analyzer of this type.

All other nondispersive infrared analyzers employ condenser microphones as wavelength-selecting radiation detectors. The microphones are filled with a gaseous sample of the material to be detected so that they respond only to infrared wavelengths that this material is capable of absorbing. For this reason this type of analyzer is often called "positive-filtering". Typically, the optical system, Figure 3, consists of two radiation paths side by side, each alternately directed to a single detector. Identical infrared sources, driven from the same power supply, illuminate each path. The process stream flows through a sample cell placed in one of the radiation paths.

In this arrangement the response of the condenser-microphone detector is due entirely to radiant power at the analytical wavelengths; all other wavelengths do not affect the detector. The detector output is thus proportional to the difference in the radiant power in the two paths at the analytical wavelengths. As in the negative-filtering analyzer, carefully controlled amounts of other ingredients of the process stream may be placed in cells in one or both radiation paths to maximize the desired response and minimize the response to interfering materials. Again the cells serve as "barreled optics". To minimize detector response to changes in ambient temperature, the radiation paths are interrupted at a fixed frequency and only the component of the detector output at this frequency is measured.

Notice that this analyzer, as well as the negative-filtering analyzer previously described, measures the difference in the radiant power in the two beams. As a consequence, in long-term use both the zero and the span of the analyzer may slowly change because of obscuring deposits on the sample cell windows, or because of a change in the power output of the source, even though equal in both beams. For this reason, it is always desirable—and often necessary—to have available at the analyzer standard samples corresponding to the maximum and minimum amounts of the desired constituent. At periodic intervals these samples are used for checking and resetting analyzer zero and span. Some analyzers incorporate optical devices for routine checking of the span, but a standard sample is necessary for checking the zero.

Distinctive features of some nondispersive selective-detector analyzers are aimed at increasing ultimate sensitivity, reducing interference, and minimizing long-term changes in span and zero. For example, in the Cary (Analytic Systems Co.), the detectors in each beam are completely independent so that different gas mixtures may be used to fill them. The *LIRA* (Mine Safety Appliances Co.) alternately interrupts the two beams of radiation with a slow-moving shutter (1.7 cps), which permits the use of optical filters instead of completely opaque sections. If filters with only slightly different transmission characteristics are used, only the radiation in a very narrow wavelength band is periodically interrupted and thus detected by the analyzer; this means addi-

tional facility in wavelength selection. The *Cary*, the *Tri-Non* (Perkin-Elmer) and one model of the *LIRA* all employ a null-balancing servomechanism to measure directly the fraction of the radiant power absorbed by the sample, instead of the actual amount of power absorbed. In the *Cary* this is accomplished by an electrical adjustment in the condenser microphone circuit, in the *LIRA* by an adjustment of the power of one of the two radiation sources, and in the *Tri-Non* by the mechanical adjustment of an optical shutter. This type of measurement tends to eliminate changes in the span of the analyzer, and to minimize the effect of some interfering substances. The *Tri-Non* analyzer has a third radiation path for further eliminating interference. A new model of the Liston-Becker analyzer (Beckman) employs a null-balanced optical shutter along with a novel arrangement of condenser microphone detectors with different fillings. This arrangement reduces both interference and changes in zero.

Selective-detector analyzers have to some extent been successfully applied to liquid as well as gas analysis. For liquid analysis, the analyzer is sensitized with vapor diluted with a permanent gas. This is often difficult with less volatile materials, however, and sometimes impossible. In such cases, the analyzer can sometimes be sensitized with a more volatile compound related to the compound of interest.

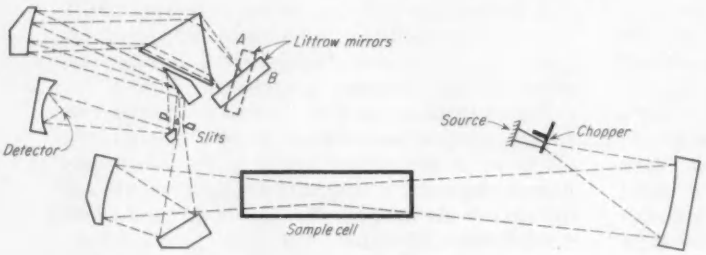


FIG. 4. Optical system of a dispersive infrared analyzer using two wavelengths. (Courtesy: Perkin-Elmer Corp.)

Dispersive analyzers

A striking feature of nondispersive analyzers is the relatively indirect way they select the analytical wavelengths, as compared with laboratory infrared spectrophotometers, which select directly, using dispersing systems with prism or diffraction gratings. There is a good reason for this. The self-filtering analyzers are usually simpler and contain less costly components. And it is more difficult to achieve long-term stability under plant conditions when a dispersing system is used than when filters of specific chemical substances are used. Once this is overcome, however, it may be possible in a dispersive instrument to enhance sensitivity and minimize interference to a greater degree than is possible with nondispersive instruments. Liquid analysis, even of nonvolatile components, becomes relatively straightforward. At present, however, dispersive instruments are more costly; they are only considered for plant use when nondispersive instruments cannot give the desired performance.

The *Bichromator* (Perkin-Elmer) combines dispersive analysis with other advantages. It isolates not just one but two selected wavelengths. Radiation from a single infrared source passes through the process-stream sample and thence into a special dispersing system where any two preselected wavelengths are isolated. A typical arrangement is shown in Figure 4. Radiation at each wavelength is alternately focused on a radiation thermocouple, where an output at the alternation frequency appears whenever the radiant power at the two wavelengths is unequal. This output is amplified and used to position a calibrated optical shutter to restore equality. The position of the calibrated shutter thus is a measure of the ratio of radiant power at the two wavelengths. Normally the wavelengths are selected so that one is strongly absorbed by the substance being measured while the other is absorbed slightly or not at all. At the same time, other substances in the mixture should absorb equally and only slightly at the two wavelengths.

This type of instrument offers two important advantages for process-stream analysis. First, unlike the self-filtering analyzer, it does not have to store a vapor of the substance being measured, and possibly of other substances in the mixture, and thus can determine substances that are too nonvolatile, too unstable, or too reactive for self-filtering methods. Second, because of the two wavelengths, both passed through the sample, the analyzer does not respond at all to certain adverse conditions, such as the buildup of fouling deposits on the windows of the sample container (provided their effect is equal at both wavelengths). The dispersive analyzer, still relatively new, should find wide use, particularly if its cost and complexity can be reduced.

Choice of analyzer

As might be expected from the foregoing descriptions, commercial infrared analyzers, although similar in operating principles, differ widely in details of design and construction. They also differ considerably in cost, ranging from approximately $2,000 to $9,000. To select an instrument, one must consider a number of factors. Usually, if the process stream can be described in detail, the manufacturer can make a reliable estimate of the attainable sensitivity and the amount of unwanted interference by other constituents of the stream. The user can then select the appropriate instrument by considering the prom-

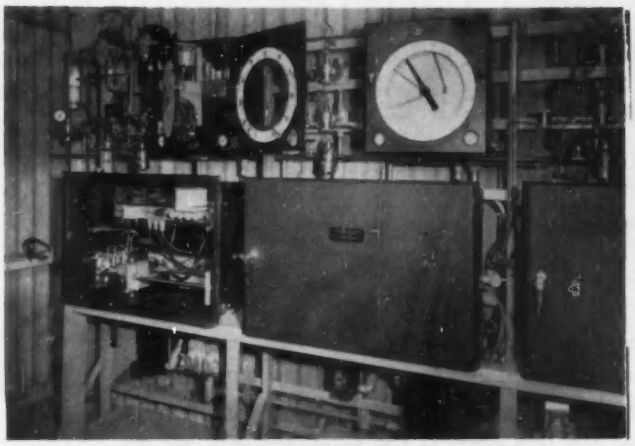


FIG. 5. Three Cary Model 70 infrared analyzers installed in a Shell Chemical Corp. plant. The ranges of these instruments are, from left to right, 0-15 percent CH_4, 0-50 ppm CO and CO_2, and 0-200 ppm CO_2.



FIG. 6. A more detailed view of an analysis section is shown in this view of Liston-Becker's (Beckman) explosion-proof unit with cover removed.

ised performance, the cost, the kind of field service the manufacturer can provide, and, for maintenance reasons, the similarity to other analyzers, if any, that are already on the plant.

Figures 5 and 6 show a plant installation of infrared analyzers and the details of an analysis unit.

Sampling conditions

One problem that cannot be overemphasized in the installation of an infrared analyzer is that of taking a sample suitable for analysis from the process stream. The sample must flow through a container having transparent windows inside a sensitive optical instrument. Needless to say, one will have difficulty in continuously analyzing a stream that already shows a tendency to plug the process piping. Generally, the precautions that may have to be taken to assure a clean sample can be assessed by examining fouling effects on glass rotameters or sight glasses in the process line. The analyzer windows will probably have to be cleaned as often as the rotameters and probably even more often. If this is too frequent, special care should be given to the selection of suitable filters for removing suspended solids and mists. Many of the sample-handling techniques enumerated by Leo Glasser ("Photometric Stream Analyzers", CONTROL ENGINEERING, October 1957) in his discussion of ultraviolet analyzers apply as well, when taken in context, to infrared analyzers. Reference 4 contains additional facts on sampling.

Future trends in infrared analyzers

The prospects for still wider use of infrared analyzers for process measurement and control in the future is very bright indeed. In fact, the present scientific literature on improved components for infrared instruments is almost too voluminous to follow. But a number of definite trends are discernible. Improved optical components should make possible process-stream analyzers at wavelengths beyond 15μ. At these longer wavelengths, the absorptions are characteristic of chemical bonds between larger atoms. If this spectral region can be exploited, infrared analysis may do as much for inorganic chemical processing as it already has for organic. In the wavelength range already being used, present developments are expected to lead to greater facility in the selection of analytical wavelengths, particularly through the use of interference filters composed of multiple layers of dielectric materials. The performance of these filters is constantly being improved, and they are becoming available.

Also certain to find extensive use are infrared detectors employing the photoconductive and other photoelectric effects in semiconductors. Detector noise is a present serious limitation in infrared analysis, and the newer detectors such as the lead sulfide photoconductor, with its much improved signal/noise ratio, are most welcome. They are already being used in laboratory infrared instruments, though not yet in process-stream analyzers. An example of what can be accomplished with these newer components is the airborne hygrometer developed by Beckman Instruments for military use[3]. The complete optical system for generating, isolating, detecting, and comparing radiation at two infrared wavelengths is contained in a volume of less than 40 cu in., and is very sensitive, reasonably simple, and robust.

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Servo Modulators-III

Semiconductor Modulators, Magnetic Modulators, and Tabulated Characteristics of Commercial Units

The typical circuits, performance characteristics, and application information for semiconductor and magnetic modulators given here complete the coverage of the four basic modulator types—electromechanical, electronic, semiconductor, and magnetic. The literature in the comprehensive list of references deals not only with the design of specific modulators, but also with many interesting modulator applications. Included this month is a four-page table listing the important characteristics of many commercially available modulators; it is the first survey of this type ever made. The last article in this group—to appear next month—will show the detailed circuitry and test-obtained characteristic curves for several modulators that were constructed because available units would not satisfy specifications.

BASIL T. BARBER, Sperry Gyroscope Co.
L. S. KLIVANS, Radioplane

Solid-state modulators use semiconductor diodes, transistor elements, dielectrics such as voltage sensitive capacitors, nonlinear resistors such as Varistors and Thyrites, thermistors, and photoconductive elements. Modulators that employ semiconductor diodes were discussed last month; the remaining types are covered below.

Transistor modulators

As a nonregenerative switch—that is, a switch that can be maintained in an altered condition only by the continued application of a minimum-level control signal—a transistor can exhibit many megohms impedance in the *off* condition and less than one ohm in the *on* condition, with a voltage drop of only a few millivolts. These characteristics make possible high-performance transistor modulators. And since the transistors are not used as amplifiers, parameter changes do not affect performance as a switch.

The switching action depends on the relative polarity of the transistor elements. Thus, when the base is positive with respect to both the emitter and the collector, the transistor is equivalent to an open switch with very low leakage impedance. When the polarity reverses, the transistor becomes a closed switch with very low voltage drop.

In designing transistor modulators, the transistor Zener voltage is of prime importance, because it determines input-signal/reference-voltage limit. If the Zener voltage is exceeded, the transistor can be destroyed. Input and output load impedances are critical, and should match parameters.

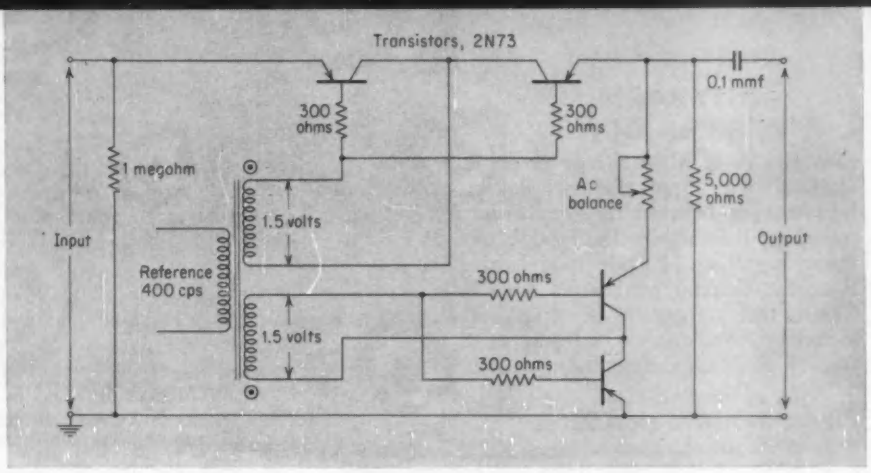
Figure 1 shows two typical transistor modulators. In general these are used at low levels when long stability is important.

Dielectric modulators

Voltage-sensitive capacitors can be used to form modulators. These capacitors derive their voltage-sensitive property from special ceramic dielectric materials—usually barium titanate—which have a dielectric constant dependent on the electric field across them. Figure 2 shows the characteristic curve of a typical unit. The change of capacitance caused by a change in the input dc voltage can be inserted in a balanced bridge, giving an ac output proportional to the dc input. Modulators designed with voltage-sensitive capacitors are used for high-input-impedance applications, especially when the dc input signal varies over a wide range.

Nonlinear-resistor modulators

There are special classes of materials whose resistance varies as a function of some outside parameter—for example, voltage, temperature, or light. These materials usually do not exhibit a rectifying action, and thus can be used in ac bridges that



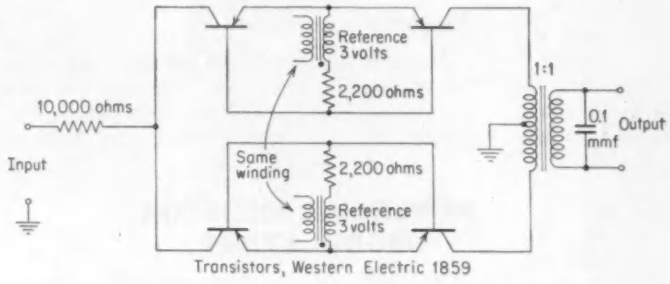


FIG. 1. Two typical transistor-modulator circuit configurations.

can produce a clean sine-wave output as a function of a dc input signal.

The Thyrites (General Electric Co.) and Varistors (International Resistance Co.) are well-known materials whose resistance varies as a function of applied voltage. They are usually made by pressing silicon carbide with a suitable ceramic binder, and then by firing at high temperature. Their volt-ampere characteristic can be approximated by

$$I = KE^n$$

where

I = instantaneous current passed by the element
E = instantaneous voltage applied to the element
K = a constant depending on the shape and size of unit
n = an exponent depending on the properties of the unit and on the operating voltage level ($n = 1$ for pure resistance).

Since n increases with increased voltage level (and can vary from 2 to 6), modulators using these elements are designed for high-voltage operation, usually greater than 1 volt. Figure 3 shows the variation of internal resistance as a function of applied voltage for a typical material, and a typical modulator circuit.

Thermistor modulators

A thermistor is a temperature-sensitive resistor with a high negative-temperature coefficient. Its internal resistance is approximately:

$$R = R_0 e^{K}$$

where:

R_0 = resistance at a reference temperature T_0
$K = B(1/T - 1/T_0)$
T = operating temperature, deg Kelvin
B = a constant depending on material

Differentiating the above equation gives the temperature coefficient

$$\alpha = \frac{1}{R}\frac{dR}{dT} \cong -\frac{B}{T^2}$$

which is constant over a given temperature range.

In a thermistor modulator, a temperature differential caused by the input current changes the thermistor's resistance. This unbalances the bridge and results in an ac output proportional to the dc input voltage. Since there are large thermal time

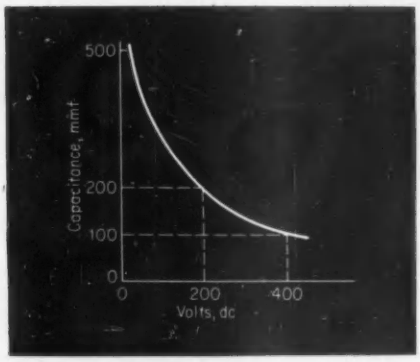


FIG. 2. Characteristic curve of a typical voltage-sensitive capacitor.

constants involved, this type of modulator can be used only with inputs that vary slowly. In addition, heat transfer between the thermistor and the surroundings may change the modulator into a transducer, resulting in poor modulator performance. Recently, thermal modulators have been used in circuits that are capable of complex computations, including differentiation, integration, and the solution of nonlinear differential equations[67].

Photoconductive modulators

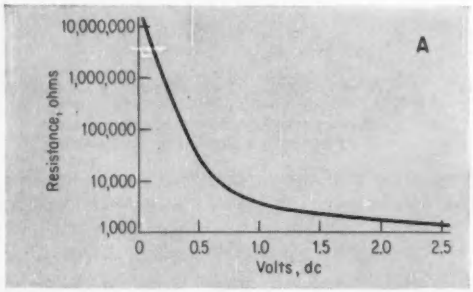
In several sulfide compounds the internal resistance is a function of the amount of light energy that falls on the exposed surface. Figure 4A shows the internal resistance of a lead sulfide cell as a function of incident light flux. By modulating the light flux from maximum to minimum intensity it is possible to use the cell as an on-off switch for modulating a dc input voltage. Figure 4B shows the configuration of a basic photoconductive modulator, Figure 5 the circuit for a specific modulator.

Since maximum sensitivity occurs around the frequency of green light, use is made of special glow lamps centered around 5,000 to 10,000 angstroms, depending on the type of sulfide. The input resistance R_1 in Figure 4B is adjusted according to the maximum obtainable resistance of the cell as indicated in Figure 4A, and according to efficiency, noise, and optimum-output-load considerations. Light modulators are used in medium level applications where low drift and long life are important. Restricted temperature range is the limiting parameter, with the highest permissible operating temperature about 80 deg C.

Magnetic modulators

Magnetic modulators use the nonlinear characteristics of magnetic materials. Although comparatively old devices, they have been used successfully only during the last decade, which saw revolutionary

A—*Variation of internal resistance with voltage for a typical voltage-sensitive resistor.*
B—*Modulator based on resistance element with the characteristic shown in A.*



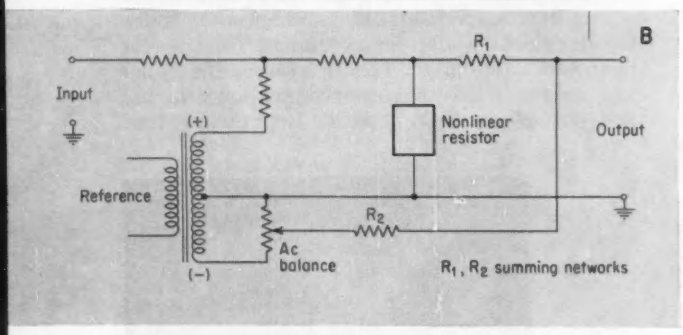


FIG. 3. Voltage-sensitive resistors.

NONLINEAR-RESISTOR MODULATORS

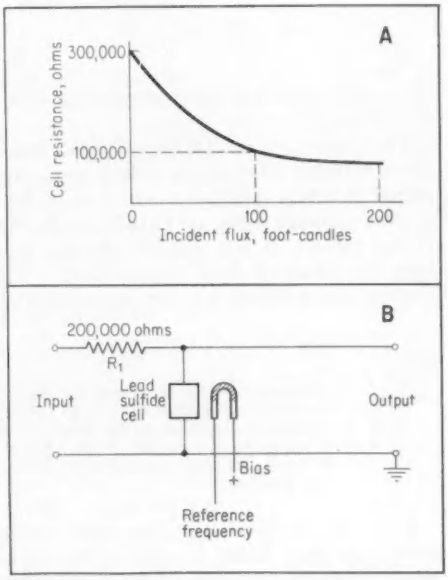


FIG. 4. Curve of lead-sulfite cell resistance vs. incident light flux, A, and the basic configuration of a photoconductive modulator, B.

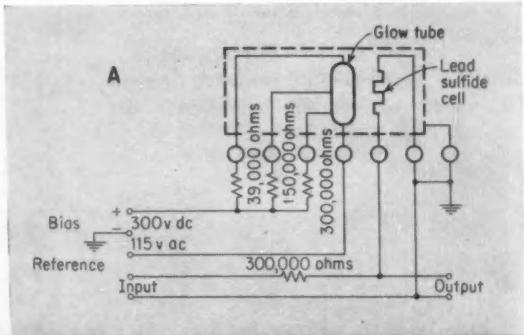
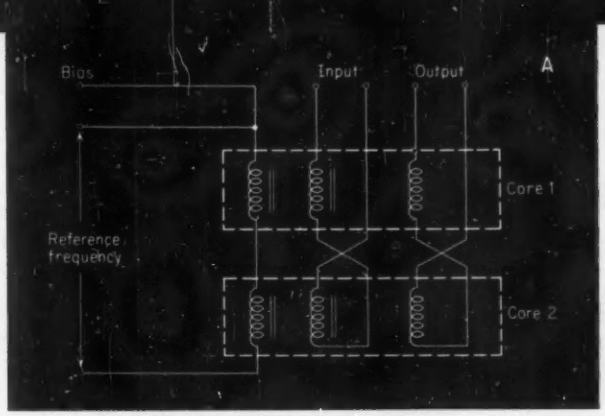


FIG. 5. Circuitry of a specific photoconductive modulator.

MAGNETIC MODULATORS



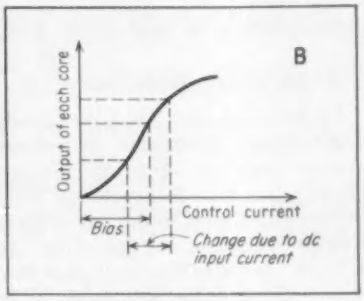


FIG. 6. Basic configuration of fundamental-frequency magnetic modulator, A, and typical performance characteristic, B.



A. Lear



B. General Magnetics

FIG. 7. Available odd-harmonic modulators.

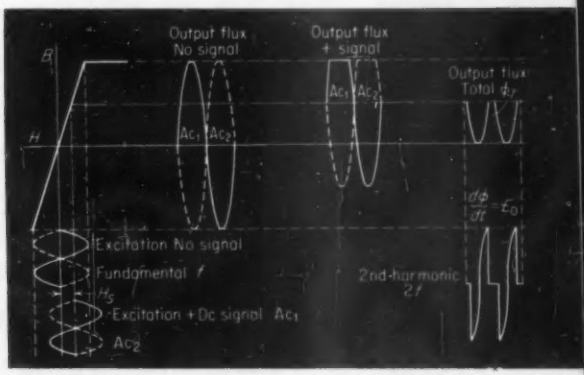


FIG. 8. In a second-harmonic modulator, the dc signal displaces the axis of symmetry[80].

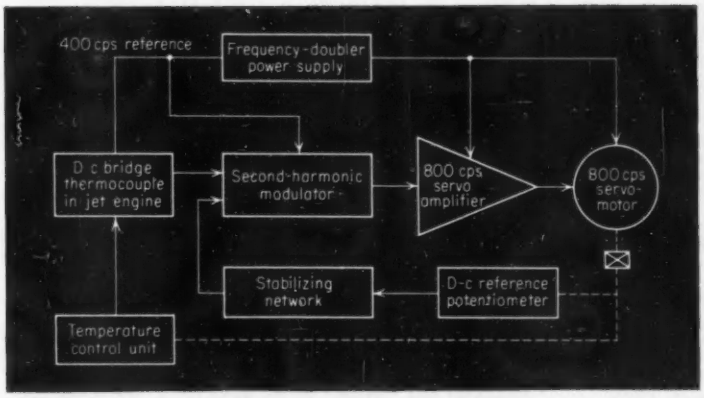


FIG. 9. Typical aircraft application of a second-harmonic modulator in a temperature-control servomechanism.

advances in high permeability magnetic materials and in diodes with very high ratios of backward-to-forward resistance. Because they are entirely static, magnetic modulators are widely used in critical applications, such as in the chemical and steel industries, and in automatic control systems for reactors.

Some magnetic modulators can be made to exhibit very high sensitivity or zero drift. Sensitivities of 10^{-19} watts per cycle of bandwidth are feasible, and modulators with this characteristic find use in magnetometers and other extremely sensitive airborne instruments for use in submarine detection and geological surveys. On the debit side, magnetic modulators have a relatively low impedance, may introduce a nonlinear time constant into a system, and are temperature-sensitive, large in size, limited in carrier-frequency range, and affected by stray fields, thermal emf's, and memory effects (due to very large input signals).

A typical magnetic modulator consists of a balanced bridge, with a number of reactors connected so that a change in dc input will change the reactances of the bridge in a differential manner, and thereby produce an ac output proportional to the dc input. There are four types: odd-harmonic, even-harmonic, flux gates and other special even-harmonic,

and bismuth-alloy modulators. Descriptions follow.

Odd-harmonic modulators

Figure 6 shows the basic configuration of an odd-harmonic modulator. The reference carrier frequency feeds two opposing coils on separate cores. During the first half-cycle of the carrier, the dc input current adds to the flux of one of the two coils and subtracts from the flux of the other coil, causing a higher primary winding impedance on the core with the opposing flux fields. The voltage drop across this primary is therefore higher, and causes a higher induced voltage across the secondary. During the other half-cycle of the carrier the dc input current still has the same polarity, but the carrier-voltage flux fields have reversed. This produces a sinusoidal output proportional to the dc input.

As is shown in Figure 6B, a bias signal is necessary to make the modulator bidirectional with an output frequency equal to that of the carrier. This imposes a severe limitation on this type of magnetic modulator, since any bias drift shows up directly as null drift on the modulator's output. Zero stability is also a problem because of the difficulty of permanently matching the magnetic cores at all points on their magnetization characteristic. Figure 7 shows two typical commercially available magnetic modulators of the odd-harmonic or fundamental-frequency type. Generally, these units are used in medium-performance automatic control applications and where reliability is the outstanding requirement.

Even-harmonic modulators

By extending the axes of the parameters shown in Figure 6B and by shifting the operating points, a modulator can be made to produce an output with basically a second-harmonic content. Figure 8 shows how this is done. The outstanding feature is an extremely low inherent zero drift (less than 5 microvolts is possible). Stability levels of 10^{-18} watts over a bandwidth of 3 cps have been recorded.

No bias is necessary, but the double frequency output is a serious limitation in carrier-operated servo systems. For this reason, applications of second-harmonic modulators are almost exclusively in very high gain stable dc amplifiers. The performance of this type modulator rivals that of the mechanical chopper. A main power supply with a flexible design can accommodate a number of instrument servomechanisms using this type modulator in conjunction with a double-frequency power supply for the servomotors. Figure 9 shows such an application.

Flux gates, peak-height modulators, etc.

These types are basically even-harmonic modulators that use special techniques to modify the *B-H* characteristics of the cores. Their application is specialized: measurement of external magnetic fields, aerial navigation and direction finding.

Bismuth-alloy modulators

These modulators utilize a class of alloys whose electrical properties can be modified by applying a magnetic field. A modulator operating on the same principle as the photoconductive type of semiconductor can therefore be constructed. Very promising results have been reported, but the units are still in the developmental stage.

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CHARACTERISTICS OF COMMERCIALLY

	MANUFACTURER	PART NUMBER	TYPE	CARRIER FREQUENCY, CPS	CARRIER VOLTAGE	MAXIMUM INPUT	MAXIMUM OUTPUT VOLTAGE
DIODE MODULATORS	BRADLEY LABORATORIES 170 G Columbus Ave. New Haven 11, Conn.	Model S-1	Silicon bridge modulator	400	2 volts rms	0 – 0.5 volt; input resistance 2,700 ohms	0-1.6 volts
	SANDERS ASSOCIATES Nashua, N. H.	Phase Comparator Model 2	Full-wave diode bridge	0 – 5,000	115 volts rms	50 volts	35 volts rms, sine wave
	SERVO CORP. OF AMERICA 20-20 Jericho Tnpk. New Hyde Park, L. I., N. Y.	Model 2315 (tentative specs.)	Diode switching	60 and 400	115 volts rms	25 volts	25 volts
	SYLVANIA ELECTRIC PRODUCTS, INC. 100 Sylvan Road Woburn, Mass.	Type 1N40	Crystal diode varistor	To 1 mc	2-4 volts rms	Not specified	Not specified
		Type 1N71	Crystal diode varistor	To 1 mc	1 volt rms	Not specified	Not specified
		Type 1N435	Crystal diode varistor	To 1 mc	0.3 volt rms	Not specified	Not specified
	TRANSITRON ELECTRONICS CORP. 168-182 Albion St. Wakefield, Mass.	Q-25	Matched germanium diode quad	To 2.5 mc	10 volts rms max.; 50 milliamp rms max.	Not specified	Not applicable (can be connected as ring or bridge modulator)
		SE-175	Matched silicon diode modulator quad	To 50 kc	4 volts rms max.; 50 milliamp rms max.	Not specified	Not applicable (can be connected as ring or bridge modulator)
MAGNETIC MODULATORS	GENERAL MAGNETICS, INC. 135 Bloomfield Ave. Bloomfield, N. J.	IMM-311-1000	Magnetic modulator	400	5-6 volts rms	150-0-150 microamp into 1,000 ohms	7 volts rms, sine wave
		IMM-439-5	Magnetic modulator	400	26 volts rms	70-0-70 microamp	7 volts rms, sine wave
		MTC-435-2	Magnetic thermo-couple converter	400	6.3 volts rms	1,000-0-1,000 microamp or 10-0-10 millivolts	2.7 volts rms, output impedance 10,000 ohms
		IMM-371-3	Magnetic modulator	400	115 volts rms	150-0-150 microamp	4.0 volts rms, output impedance 500 ohms
		IMM-411-1	Magnetic modulator	400	26 volts rms	100-0-100 microamp	2.0 volts rms, 2 outputs, output impedance 200 ohms for each winding
	LEAR CAL DIV. LEAR, INC. 3171 S. Bundy Dr. Santa Monica, Calif.	Model F5A series	Magnetic modulator	Standard – 60 cps to 10 kc Low impedance models to 100 kc	Fraction of a volt, nominal excitation current 200 microamp, impedance varies with dc bias	0-200 microamp into modulator with 70-ohm signal winding; current and voltage sensitivity change with signal winding resistance	2-3 volts rms sine wave from high-impedance winding of suitable output transformer
	MINNEAPOLIS-HONEYWELL REG. CO. Boston Div. 1400 Soldiers Field Rd. Boston 35, Mass.	Model 2H-2	Second-harmonic magnetic converter	To 2,500	6.3 volts rms at 1,200 cps	10 millivolts into 550 ohms	1 volt at 2,500 cps

AVAILABLE SERVO MODULATORS

LIFE EXPECTANCY	MAXIMUM AMBIENT TEMPERATURE	SEALING ARRANGEMENT	MOUNTING	SIZE	WEIGHT	CONTACT CLOSURE, PERCENT	MODULATION FREQUENCY RESPONSE, CPS	PHASE SHIFT	NOISE LEVEL
Not specified	−55 to +85 deg C	Not specified	Not specified	Not specified	Not specified	Not applicable	Not specified	Not specified	10 millivolt max. at room temperature; 15 millivolt max. over temperature range
Not specified	125 deg C	Hermetically sealed	8-pin octal	Diam—1 in. Height—3 in.	2 oz	Conversion efficiency 85 percent	20 percent of carrier frequency	In phase with external capacitor	Dynamic range 46 db
5,000 hours	100 deg C	Hermetic sealing available	Plug-in chassis	3 x 7 x 9 in.	4 lb	Not applicable	10 percent of carrier	Not applicable	0.5 millivolt
500 hours minimum	−50 to −75 deg C	Not specified	8-pin octal	Max. diam 1.312 in. Seated height 1⅛ in.	Not specified	Not applicable	Not specified	Not specified	Not specified
500 hours minimum	−55 to −90 deg C	Not specified	8-pin octal	Max. diam 1.312 in. Seated height 1⅛ in.	Not specified	Not applicable	Not specified	Not specified	Not specified
500 hours minimum	−50 to −75 deg C	Not specified	8-pin octal	Max. diam 1.312 in. Seated height 1⅛ in.	Not specified	Not applicable	Not specified	Not specified	Not specified
Not specified	85 deg C	Hermetically sealed	7-pin subminiature	Length ¾ in. Width 5/16 in. Height ¾ in.	0.2 oz	Not applicable	About 20 percent of carrier (higher in low impedance circuits)	Zero	5 millivolts unbalance voltage; 5 microamp unbalance current (can be nulled with dc bias or balancing resistance)
Not specified	150 deg C	Hermetically sealed	7-pin subminiature	Length ¾ in. Width 5/16 in. Height ¾ in.	0.2 oz	Not applicable	About 20 percent of carrier (higher in low impedance circuits)	Zero	5 millivolts unbalance voltage; 0.05 microamp unbalance current (can be nulled with dc bias or balancing resistance
Unlimited	−75 to +200 deg C	Hermetically sealed	Studs and 10-pin solder header	1 x 1 1/16 x 1¾ in.	4 oz	Not applicable	0.1 sec for 100,000 ohm source	0 to ± 10 deg or 180 ± 10 deg	25 millivolts rms (0.5 percent of max. output)
Unlimited	−75 to −200 deg C	Hermetically sealed	Studs and 10-pin solder header	1⅛ x 1¼ x 1⅞ in.	4.5 oz	Not applicable	0.1 sec for 500,000 ohm source	0 to ± 10 deg or 180 ± 10 deg	25 millivolts rms (0.5 percent of max. output)
Unlimited	−75 to −200 deg C	Hermetically sealed	Studs and 10-pin solder header	1¼ x 1⅛ x 5/8 in.	15 oz	Not applicable	0.1 sec for 1,000 ohm source	0 to ± 10 deg or 180 ± 10 deg	15 millivolts max. (0.5 percent of max. output)
Unlimited	−75 to −200 deg C	Hermetically sealed	Studs and 10-pin solder header	1⅛ x 1⅛ x 1¾ in.	4.5 oz	Not applicable	0.1 sec for 500,000 ohm source	0 to ± 10 deg or 180 ± 10 deg	20 millivolts max. (0.5 percent of max. output)
Unlimited	−75 to −200 deg C	Hermetically sealed	Studs and 10-pin solder header	1⅛ x 1⅛ x 1¾ in.	4.5 oz	Not applicable	0.1 sec for 1 megohm source	0 to ± 10 deg or 180 ± 10 deg	10 millivolts rms (0.5 percent of max. output)
Unlimited	100 deg C	Hermetically sealed	Two 6-32 mtg. bolts, 1 3/32-in. centers, 7-terminal header	1 x ¾ x 1⅝ in.	2 oz	Not applicable	Optimum — 1 cycle of carrier frequency Typical — 2-5 cycles	0 to ± 5 deg or 180 ± 5 deg	Less than 10 microamp equivalent input signal in a 70-ohm modulator
Unlimited	165 deg F	Hermetically sealed in Hysol	Two studs with 11 8-in. leads	Diam 1 1/32 in. Height 2 9/16 in.	About ½ lb	Not applicable	5 percent of carrier	Not applicable	2-5 microvolts

ELECTROMECHANICAL MODULATORS

MANUFACTURER	PART NUMBER	TYPE	CARRIER FREQUENCY, CPS	CARRIER VOLTAGE	MAXIMUM INPUT	MAXIMUM OUTPUT VOLTAGE
AIRPAX PRODUCTS CO. **Cambridge Div.** **Cambridge, Md.**	Type 175 Series 300, 310, 320 Series 350	Chopper	60 or 400	6.3 volts rms	0-100 volts at 0-2 milliamp	Square wave; same as input
THE BRISTOL CO. **Waterbury 20, Conn.**	"Syncroverter" chopper	Chopper	0-1,800	6.3 volts; sine, square, pulse wave	0-10 volts at 1 milliamp	Square wave; same as input
JAMES VIBRAPOWR CO. **4050 N. Rockwell-** **Chicago 18, Ill.**	"1200" Series (low frequency)	Chopper	10-120	6.3 volts rms	0-10 volts at 1 milliamp	Square wave; same as input
	"1200" series (high frequency)	Chopper	350-500	6.3 volts rms	0-10 volts at 1 milliamp	Square wave; same as input
	"1900" series Frequency doubler	Chopper	10-120 350-500	6.3 volts rms	0-10 volts at 1 milliamp	Square wave; same as input
	"1800" series	Chopper	55-65	6.3 volts rms	0-50 volts at 1 milliamp	Square wave; same as input
LEEDS & NORTHRUP CO. **4901 Stenton Ave.** **Philadelphia 44, Pa.**	Std. 3338 series 354000 series	Chopper	25, 50, 60, 94	6.3 volts and 19 volts rms	0-5 volts at 5 milliamp	Square wave; same as input
MILLIVAC INSTRUMENT CORP. **P. O. Box 997** **Schenectady, N. Y.**	M-91	Chopper	120 cps	200 millivolts, 1.2 amp	100 volts max.; input impedance 11 megohm	Square wave; same as input
MINNEAPOLIS-HONEYWELL REG. CO. **Brown Instrument Div.** **Philadelphia 44, Pa.**	354210	Chopper	20-30, 40-50, 50-60	6.3 volts rms	6 volts max. at 1 milliamp max.	Square wave; same as input
	355081	Chopper	400	18 volts rms	6 volts max. at 1 milliamp max.	Square wave; same as input
OAK MANUFACTURING CO. **1260 N. Claybourn Ave.** **Chicago 10, Ill.**	600 series	Chopper	60, 100, 400, 600	6-12 volts	1-10 volts at 1-10 milliamp (continuous); 0-10 volts at 1-10 milliamp (intermittent)	Square wave; same as input
	M series	Chopper	0-1,000 (aperiodic operation)	1-28 volts	0-3 volts at 0-1 milliamp	Square wave; same as input
SERVOMECHANISMS, INC. **Mechatrol Div.** **625 Main Street** **Westbury, L. I., N. Y.**	MA 207	Chopper with amplifier	60	6.3 volts rms	100 volts; input impedance 0.5 megohm	40 volts rms, low distortion sinusoid, output 56,000 ohms
	MA 102	Chopper with amplifier	400	6.3 volts rms ± 10 percent	150-300 volts at 2 milliamp	50 volts rms, low distortion sinusoid, output 30,000 ohms
STEVENS-ARNOLD, INC. **22 Elkins St.** **South Boston 27, Mass.**	Catalog 370 (22 types)	Chopper	50, 60, 94, 120	6.3 volts rms	Gold alloy contacts: 0-1.5 volts at 1 milliamp Platinum-rhodium contacts: 1-50 volts at 5 milliamp (may be exceeded)	Square wave; same as input
	Frequency doubler Catalog 370	Chopper	50 cps drive with 100 cps output; 60 cps drive with 120 cps output	6.3 volts rms		Square wave; same as input
WESTON ELECTRICAL INST. CORP. **614 Frelinghuysen Ave.** **Newark 12, N. J.**	Model 140B	Induction modulator	60-1,000	24 to 115 volts rms	30-0-30 microamp into 1,245 ohms	1.9 volts rms, sine wave

LIFE EXPECTANCY	MAXIMUM AMBIENT TEMPERATURE	SEALING ARRANGEMENT	MOUNTING	SIZE	WEIGHT	CONTACT CLOSURE, PERCENT	MODULATION FREQUENCY RESPONSE, CPS	PHASE SHIFT	NOISE LEVEL
2,000 hrs minimum	Standard + 100 and + 125 deg C; up to 200 deg C on special order	Hermetically sealed	7-pin miniature plug-in, or solder lug octal plug-in	7-pin D—¾ in. H—1¾ in. (including pins) 8-pin D—1½ in. H—3⅛ in. (including pins)	7-pin: 1 oz 8-pin: 6 oz	60 cps 167/360 = 46 percent 400 cps 147/360 = 40 percent	About 20 percent of carrier frequency	60 cps 20 deg lag 400 cps 67 deg lag	60 cps 50 microvolts average into 1 meghom 400 cps 1.5 microvolts peak-to-peak into 1 megohm
10^9 cycles minimum	125 deg C	Hermetically sealed	7-pin miniature socket, or flange mounted (2- or 4-hole)	With shield D—1⅛₄ in. H—2 in. Without shield D—0.870 in. H—1½ in.	Less than 2 oz	60 cps B-B-M 99 percent 400 cps B-B-M 95 percent	About 20 percent of carrier frequency	13 deg at 60 cps; 55 deg at 400 cps; 100 deg at 1,600 cps	10 microvolts rms into 1.0 megohm (less than 100 microvolts peak-to-peak)
1,000 hours minimum	85 deg C	Hermetic sealing available	Octal and 9-pin miniature bases	D—1½ in. H—2¹¹⁄₁₆ in. D—1¹⁄₁₆ in. H—2½ in.	100 grams; 140 grams	From 30 to 60 percent closures	About 20 percent of carrier frequency	17 deg at 60 cps	Less than 1 microvolt into 0.25 megohm
1,000 hours minimum	85 deg C	Hermetic sealing available	Octal and 9-pin miniature bases		100 grams; 140 grams	From 30 to 60 percent closures	About 20 percent of carrier frequency	70 deg at 400 cps	Less than 1 microvolt into 20,000 ohms
1,000 hours minimum	85 deg C	Hermetic sealing available	Octal base	D—1½ in. H—2½ in.	100 grams; 140 grams	45 percent at double drive frequency	About 20 percent of carrier frequency	17 deg at 60 cps 70 deg at 400 cps	Carrier frequency noise can be filtered completely
1,000 hours minimum	60 deg C	Dust seal	Octal base	D—1½ in. H—2½ in.	75 grams	45 percent closure	About 20 percent of carrier frequency	26 deg at 60 cps	Less than 1 millivolt into 1 megohm
Not specified	60 deg C	Dust seal	8-pin octal	D—1.8 in. H—5.25 in. D—1.5 in. H—3.34 in.	310 grams; 155 grams	M-B-B 58 percent B-B-M 42 percent	About 20 percent of carrier frequency	40 deg lag	1 microvolt into 1 megohm
5 years	60 deg C	Hermetically sealed	Special insulation block; glass bushing terminals	7⅜x2x2 in.	39 oz	SPST, exactly 50 percent (tuned modulator)	About 20 percent of carrier frequency	90 deg ± 15 deg (tuned)	1 microvolt into 11 megohms
Indefinitely long (some in use as long as 17 years)	140 deg F	Dust seal	6-pin socket	D—2⁵⁄₁₆ in. H—3¹³⁄₃₂ in.	8 oz	M-B-B 55 percent B-B-M 45 percent	About 20 percent of carrier frequency	17 deg ± 5 deg	2×10^{-10} volts per ohm input impedance
	140 deg F	Dust seal	6-pin socket	D—2⁵⁄₁₆ in. H—3¹³⁄₃₂ in.	8 oz	M-B-B 55 percent B-B-M 45 percent	About 20 percent of carrier frequency	45 deg ± 5 deg	2×10^{-10} volts per ohm input impedance
1,000 hours (within power contact rating)	− 65 to + 125 deg C	Hermetically sealed	7-pin plug-in or solder header	Fits JAN socket and shield	Less than 1 oz	Maximum ON time 145 electrical deg	About 20 percent of carrier frequency	65 deg at 400 cps; 25 deg at 60 cps	60 cps Max. 450 microvolts rms into 1 megohm 400 cps Max. 100 microvolts rms into 1 megohm
Over 1,000 hours at low levels	− 50 to + 100 deg C	Coil and switch separately sealed	7-pin plug-in or solder header	Fits JAN socket and shield (minimum package ½x1.4 in.)	Less than ¾ oz	Maximum ON time 165 electrical deg	About 20 percent of carrier frequency	55 deg at 400 cps; 20-25 deg at 60 cps	400 cps Max. 400 microvolts rms into 1 megohm Max. 75 microvolts into 2,000 ohms; Max. 10 microvolts rms into 2,000 ohms
Over 1,000 hours	+ 170 deg F	Meets USAF specification AN-E-19	4 Dzus, AN size 2 stud with mating Winchester connector Type QRE 12S	3⅜x4⅜x 4³⁄₃₂ (high) in.	About 2 lbs	85 percent	About 20 percent of carrier frequency	0 to ± 10 deg referenced to 60 cps source	Not specified
Over 1,000 hours	+ 170 deg F	Meets USAF specification AN-E-19		2⁵⁄₁₆x4¾x 5⅛ (high) in.	About 1.5 lbs	90 percent	About 20 percent of carrier frequency	35 ± 20 deg lead	Not specified
Virtually unlimited life	43 deg C	Hermetic sealing available	8-pin octal	Max. diam 1⅞ in. Max. height 3⅜ in.	Not specified	M-B-B 55 percent B-B-M 45 percent	About 20 percent of carrier frequency	19 deg lag at 50 cps 22 deg 60 38 deg 94 43 deg 120	1 microvolt into 0.1 megohm
Virtually unlimited life	43 deg C	Hermetic sealing available	8-pin octal	Max. diam 1⅞ in. Max. height 3⅜ in.	Not specified	M-B-B 55 percent B-B-M 45 percent	About 1 cps	Not applicable	1 microvolt into 0.1 megohm
Not specified	− 55 to + 85 deg C	Hermetically sealed	5-pin solder header	D—1.05 in. H—2.73 in.	5 oz	Not applicable	Undamped period 0.25 sec	22 deg lag	Null voltage 1 percent

Pinwheels Pick Post

London's General Post Office is using a high-speed letter-sorting machine with several interesting features, one of which is a bank of mechanical pinwheels that remember the address of a letter.



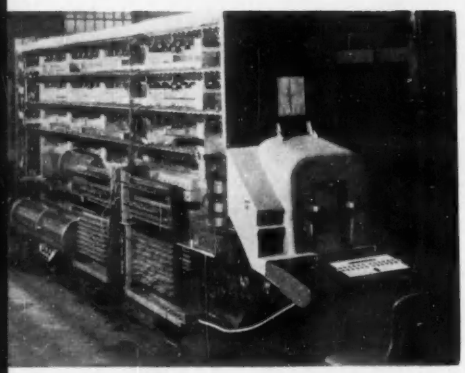


FIG. 1. A and B— Front and rear views of letter sorting machine

Twenty high-speed electromechanical letter sorters are being installed in post offices throughout Britain. These 2¾-ton machines sort nearly 6,000 letters per hour in sizes up to 7¼ by 5¼ in. into any one of 120 different pigeonholes. The pigeonholes are selected by an operator from a 24-position keyboard by depressing two keys corresponding to the initial letters of the significant address.

The letter sorter

The machine is shown in Figure 1 and consists of four main parts: the letter feed conveyor, presentation unit, main conveyor, and the selective conveyor system. The letter feed conveyor band, located in the middle of the machine, carries the stack of unsorted mail to the presentation unit and by a series of increasing-speed belts, the letters are tipped horizontally into a stack whose height is controlled by a photocell system operating on the stack feed motor.

A suction pickup in the presentation unit places the letters one at a time on a screw conveyor which faces them in turn against two viewing windows from which they pass to the main conveyor. The two viewing windows speed operation; an experienced operator reads the address on the letter in the upper window while keying the combination in the lower.

Operation of the coding keys appropriate to the letter destination allows the letter to pass on to the main conveyor. At the same time, a single-revolution clutch and cams move the next letter to the viewing window and collect a third from the stack.

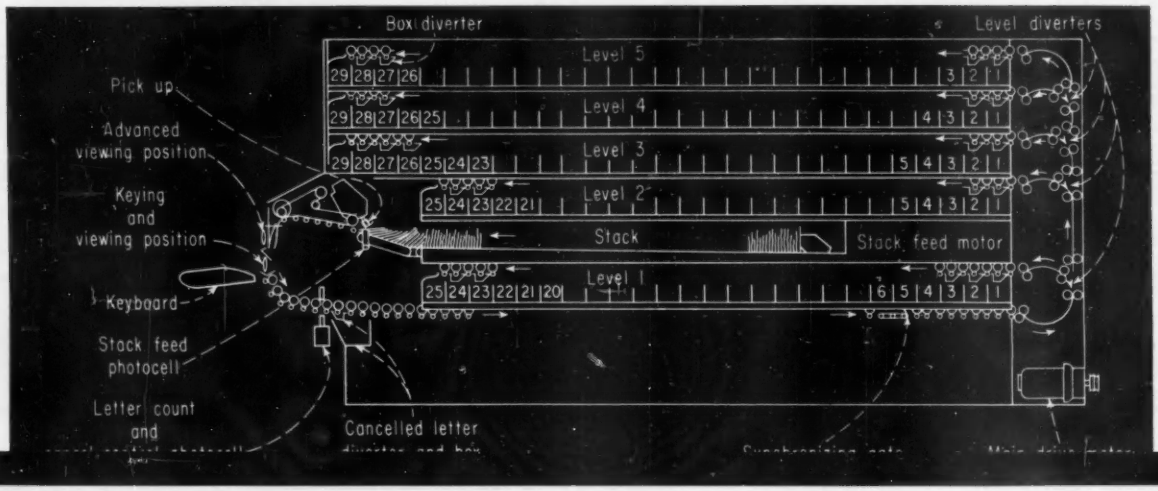
Varying address deciphering times, as well as normal fatigue, required that the operator be independent of the machine rhythm. This was solved by a synchronizing gate that enables the letters arriving on the main conveyor at random times to be synchronized with the machine memory system.

After synchronization the letters are fed by a roller conveyor system (with anti-jamming centrifugal switches in every sixth roller) to the selector system. The selector system has five horizontal conveyors situated over five rows of stacking boxes fed by a vertical distributor. Diverter blades operated by mechanical linkages from pinwheel memories in the control system divert the letters to the correct row and stacking box.

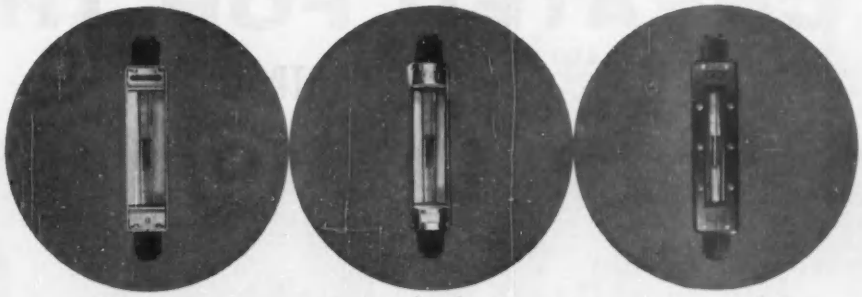
The control system

Twelve left-hand and 12 right-hand keys select the appropriate destination box, depression of any two being required for operation. In addition, a feed key lets the operator manually remove incorrectly addressed letters

C—Schematic points out major parts.



the design you want...

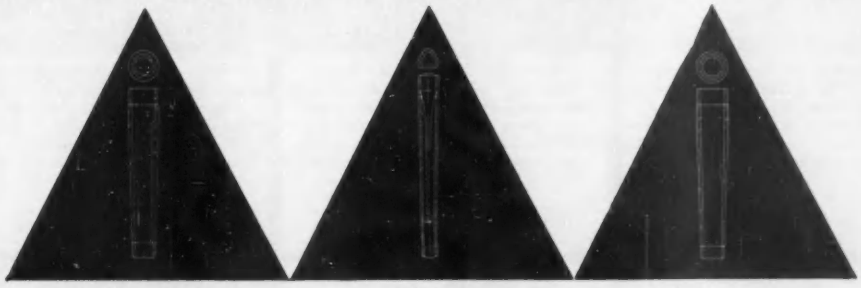


sideplate
Rugged general-purpose basic design. For non-hazardous uses.

enclosed
Attractive design with stainless bezel; gasketed safety glass cover.

pressure sealed
Strongest of all. Resists breakage. Contains liquid if glass ruptures.

with the right glass tube...

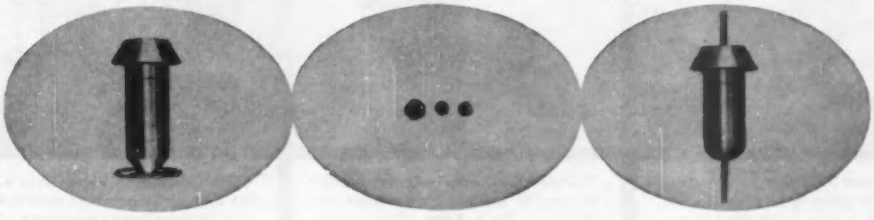


bead guide
For general use giving high accuracy over wide range.

tri-flat
For use with ball floats to meter low flow rates.

plain tapered
For special fluids and those containing solid particles.

and float...



nail head
2 types, 7 sizes for use with bead guide tubes.

ball
4 materials in 3 sizes for tri-flat tubes.

special
For highly corrosive fluids or specialty applications.

make these stainless steel enclosed flowmeters the right choice for corrosive conditions

These engineering alternatives just begin to describe the reasons why the 1700 Series variable area Flowrator meters offer the right solution to corrosion problems. Further, you can select from more than twenty different proven materials for corrosion-proof end fittings and floats. Add to this the stainless steel enclosure for all models, plus the neoprene backed Teflon packing liners, and the applications of the 1700 Flowrator are limited only by those that would affect glass.

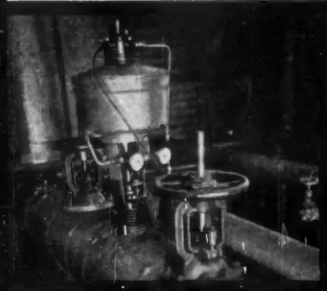
All 1700 Series Flowrators embody proven engineering principles for measuring any flow accurately up to 200 gpm of water, 400 scfm of air. Pipe connections—horizontal or vertical, screwed or flanged—can be made from any direction through a provision for 360° rotation of connection. Full data on the 1700 Series is given in Catalog 10-A-25. For your copy, write Fischer & Porter Company, 817 County Line Road, Hatboro, Pennsylvania.

FISCHER & PORTER CO.

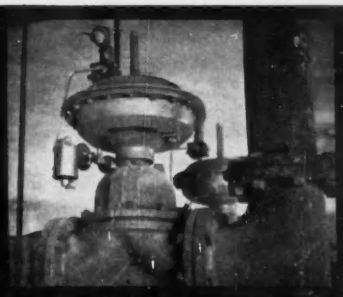
Complete Process Instrumentation

CREATED FOR THE JOB

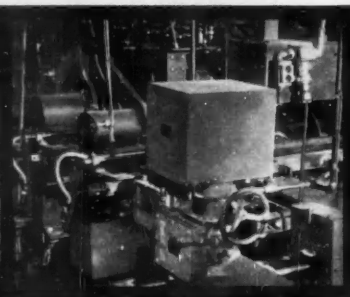
by CONOCONTROLS Specialists



Conoflow LB Valve on a difficult liquid level control job in a Barrett Div. plant of Allied Chemical & Dye Corp. This valve is handling hot coal tar at temperatures to 750° F.



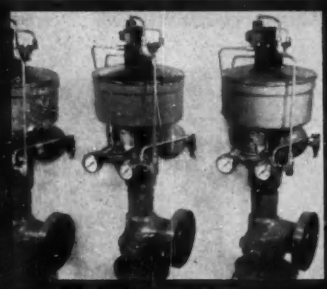
Conoflow Saunders Valves used in conjunction with Fuller Company's Airveyor System in a midwestern cement plant. These close-coupled "on-off" valves are equipped with solenoids and armored position indicators.



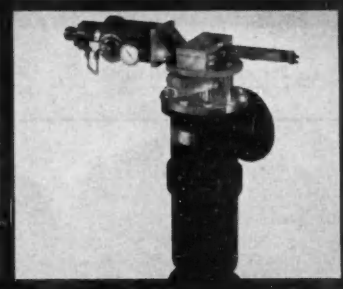
One of several Conoflow Rotomotors on a unique service in Owens-Corning's Newark, Ohio plant. This powerful pneumatic actuator positions a large circular saw which automatically trims and cuts a continuous sheet of Fiberglas into stock widths.



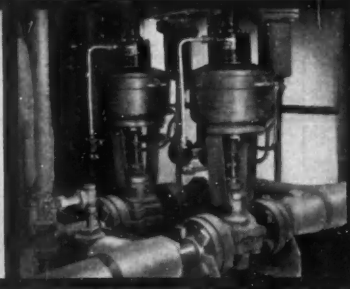
Conoflow Pressure Transmitters for the Kraft Foods Company. They will be used with miniature recorder-controllers to give visual indication and record of levels and pressures in vegetable oil vessels.



These 3" Conoflow "S" Valves are going to the Aluminum Co. of America in the new St. Louis pilot plant. They will be handling hot flashing caustic liquor containing 7% suspended solids with pressure drops up to 300 psi.



Cylinder Conomotor affords remote manual or automatic adjustment of flow rate for a Kates direct-acting flow regulator. This is one of many OEM applications for Conoflow's versatile pneumatic throttling actuator.



These Conoflow LB Valves have been on a tough temperature control service for over three years in the plant of this large manufacturer of floor covering and insulation. More than 600 Conoflow LB Valves are in use throughout this plant.



Conoflow Airpak filter-regulators being tested prior to shipment to duPont. Other large volume Airpak users are: Phillips Petroleum, Leeds & Northrup, Catalytic Construction, Minneapolis-Honeywell, and Fischer & Porter.

While most Conoflow products are shelf items—a good many are not. They are created for the job through our engineering and yours—combined and concentrated on your problem. Shown above are only a few examples of the variety and scope of Conoflow installations. If you are not already a Conoflow customer, phone or write us at 2100 Arch Street, Philadelphia 3, Pa. We'll put you in touch with a Conoflow representative qualified to help you.

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CONOFLOW CORPORATION

FOREMOST IN FINAL CONTROL ELEMENTS

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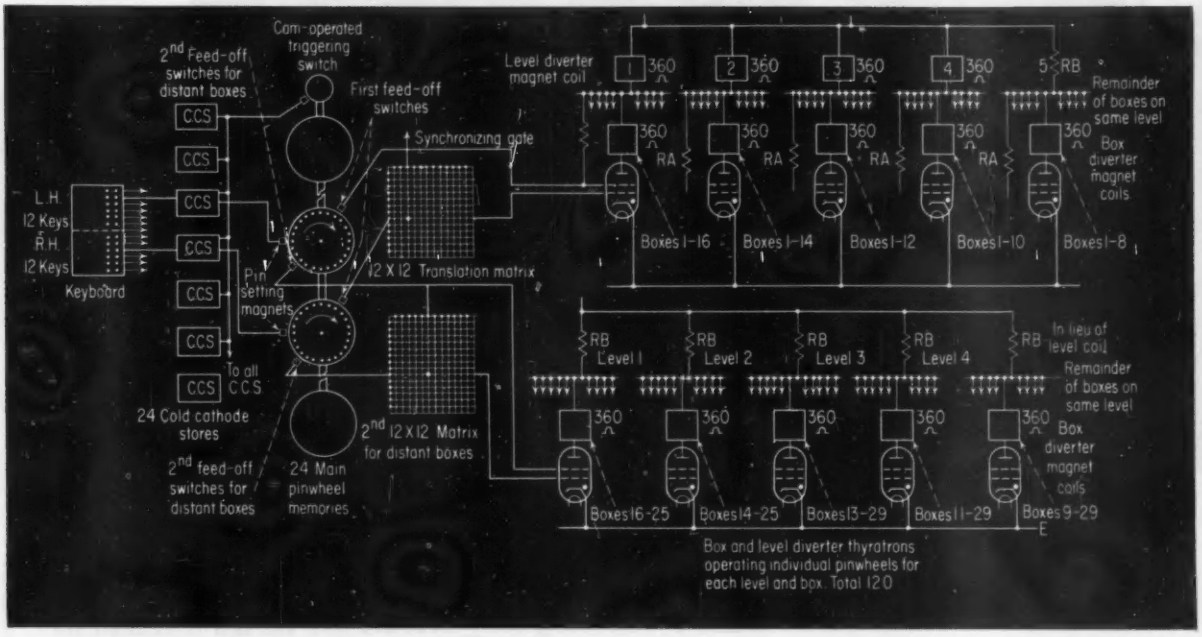


FIG. 2. Control system for high-speed letter sorter.

without delay by advancing the presentation unit one cycle and dispatches the faulty letter to an overflow box. Still another key (cancel) enables him to cancel the previous information in the event of a mistake and routes it to a cancellation box.

As shown in Figure 2, associated with each of the 24 keys is a cold cathode store and a main pinwheel memory. The cold cathode store "remembers" depression of the keys up to ½ sec, which is the time between successive pins of the memory wheel. Cam-operated microswitches are coupled to the main pinwheel drive. The microswitches apply anode voltage to the 24 thyratron tubes on the arrival of a pin in its correct triggering position, thus conveying the keyed information onto its appropriate pinwheel.

The main pinwheel memory has 24 separate pinwheels on a common shaft, Figure 3. The keyed information is stored until the letter reaches the synchronizing gate, where it is held until the pins in the main memory wheels operate microswitches to open the gate. These reading-off switches from each pinwheel are also connected into a 12-by-12-thyratron translation matrix. Two-grid thyratrons are used, one grid operating on the column information and the second on the row information. The firing of the row and column cross-point thyratron performs the translation from code form to individual selection. The thyratrons in this matrix operate smaller pinwheel memories associated with the level selectors and stacking boxes.

When released from the synchronizing gate, the letter travels in synchronization with the pinwheels so that it is routed first to the correct level and then to the correct box. Due to the small storage capacity of the box selector pinwheels, an additional delay has to be incorporated to deal with the more distant boxes. This is provided by a second bank of reading-off switches operating 5 sec after the first bank. These switches operate a second 12-by-12 matrix which sets the pinwheels associated with the more distant boxes.

Inward sorting (sorting of letters for delivery in a town) may call for a different arrangement of the stacking boxes than outward sorting (outside town areas). Therefore, program plugs are provided to reset the connection between the main pinwheels and the translation matrix.

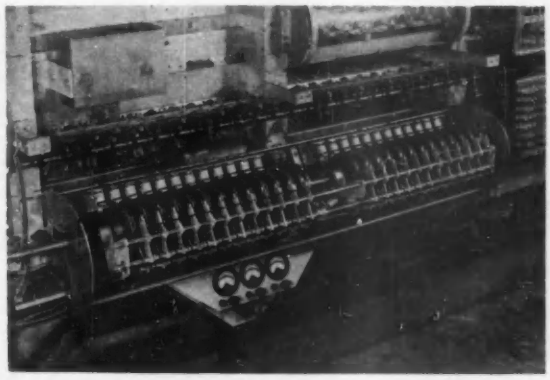


FIG. 3. Main pinwheel mechanical memory.



MICROAMMETER-MILLIVOLTMETER RECORDER PERFORMS 6 FUNCTIONS

1. **Measures low-level dc signals with calibration accuracy within 0.5%, and sensitivity within 0.2% of span.**
2. **Records on 3" continuous strip chart or IBM-type card chart, with linear coordinates.**
3. **Positions recording pen with force many thousand times greater than usual direct-deflection electrical movements.**
4. **Operates on force-balance principle—compensates for ambient conditions, changes in power supply and components.**
5. **Records fast—up to 0.05 seconds for 63% of fullscale changes.**
6. **Provides span and zero adjustments for easy calibration and zero suppression in the field, without special equipment.**

Here's How To Get POSITIVE, ACCURATE Records of Electrical Measurements ALL THE TIME...

This highly sensitive 'American-Microsen' Series 130 Recorder, with all its operational advantages, costs less than others designed for the same jobs. Simple design, precision components and rugged construction assure sustained high accuracy and freedom from maintenance. The recorder withstands shock up to 30 times gravity.

Since its introduction less than a year ago, the Series 130 Recorder has been very successful because it offers a more accurate and durable method of recording dc electrical signals at lower cost. It is being used to record outputs of many different electrical transducers — for measurement of such variables as pH, gas analysis, signal strength and others.

Many laboratories have adapted the Series 130 Recorder to their analytical and scientific instruments to assure accurate, permanent records of results which previously were only indicated. The Recorder can be used with any device which can provide 200 microamperes or more in its output circuit.

Standard 'American-Microsen' Series 130 Recorders are priced at $250.00. All models have ample power to operate alarm contacts which can be supplied at extra cost. *Write for Bulletin MG10.*

SPECIFICATION BRIEFS

POWER SUPPLY: 115 volts, 60 cycles. **POWER REQUIREMENT:** 9 watts.

INPUT RANGES: Voltage — 0-20 millivolts to 0-100 volts dc. **Current** — 0-200 microamperes to 0-100 milliamperes dc. **Input Sensitivity** — 6700 ohms per volts.

ACCURACY: ± 0.5% of span. **SENSITIVITY:** ± 0.2% of span. **REPEATABILITY:** ± 0.25% of span.

EFFECT OF SUPPLY VOLTAGE: Less than 0.5% error 90-130 volts.

EFFECT OF AMBIENT TEMPERATURE: Less than 0.5% error 50° to 100° F., and less than 1% to 130° F.

RESPONSE TIME: Fast Speed — 0.2 seconds standard for 63% of fullscale input change; up to 0.05 seconds for 63% on special order. **Slow Speed**— approximately 4 times fast speed setting.

CHART SPEEDS: Strip Chart — 1" per hr., standard; 3" or 6" per hr. available. **Card Chart** — 1 rotation per day, standard.

SPAN ADJUSTMENT: ± 10% of span. **ZERO ADJUSTMENT:** ± 100% of span.

PANEL SPACE REQUIRED: Only 27 square inches.

MANNING, MAXWELL & MOORE, INC.

MAXWELL MANNING M&M MOORE INC. TRADE MARK

INDUSTRIAL CONTROLS DIVISION • STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATORS, RECORDERS, CONTROLLERS, ELECTRO-PNEUMATIC VALVE POSITIONERS AND ELECTRO-HYDRAULIC CONTROL VALVE OPERATORS.

Blending Liquids by Electronic Process Control

The use of simple force-balance computers enables blending ratios between several liquids to be maintained irrespective of changes in master flow.

G. L. LAWS Evershed & Vignoles, London

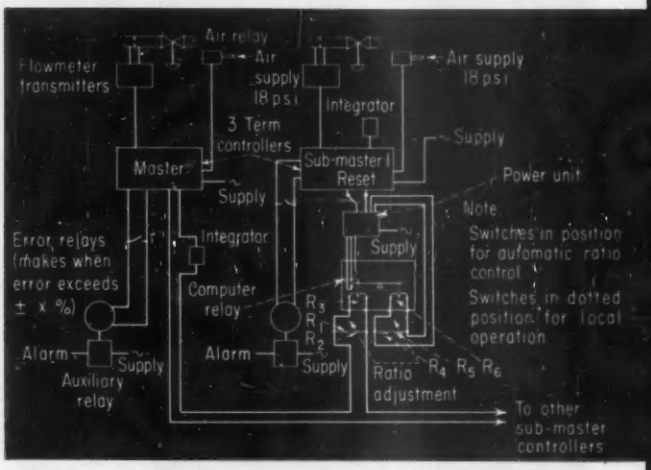


FIG. 1. Schematic diagram of constant-ratio control system.

In many oil refineries and petrochemical plants, accurate blending of a number of liquids must be maintained in a preset ratio. Blending can be controlled automatically by setting the control values on each flow line to a desired ratio with respect to the master flow line. The accuracy of blend will then depend entirely on the time taken by the controller on each flow line to regain desired value after a plant upset.

A disadvantage, however, is that if the desired value of the master flow controller has to be adjusted during a blending operation, simultaneous adjustments are necessary on all the other flow line controllers to maintain the product blend.

To avoid this complex operating procedure, some means is required to automatically adjust the desired value of the controllers when any change occurs in the master flow line. The ratios required would be set before startup and automatically maintained at a desired value which would be constantly corrected for any change in master flow.

This has been accomplished at the Imperial Oil Refinery, Halifax, Canada, by using three-term controllers and simple force-balance computers, as shown in Figure 1.

Each flow line is fitted with an electronic force-balance flow transmitter. A differential pressure proportional to flow is derived from an orifice plate or venturi tube and fed to each side of the diaphragm of a dry-diaphragm flow transmitter. Square law correction is obtained electrically in the transmitters, and each transmitter produces a 0-15-ma dc output directly proportional to instantaneous flow. These outputs go to three-term controllers, as shown in the schematic diagram.

The controller outputs, also 0-15 ma dc, operate valve positioners which apply a proportional air pressure, 3-15 psi, to the top of a conventional air-operated diaphragm control valve. The master flow is controlled directly by the three-term electronic controller at the desired-value set-point. But the values of all the sub-master controllers are automatically adjusted by computers interposed between each sub-master controller and the master con-

FIG. 2. The force-balance computer.

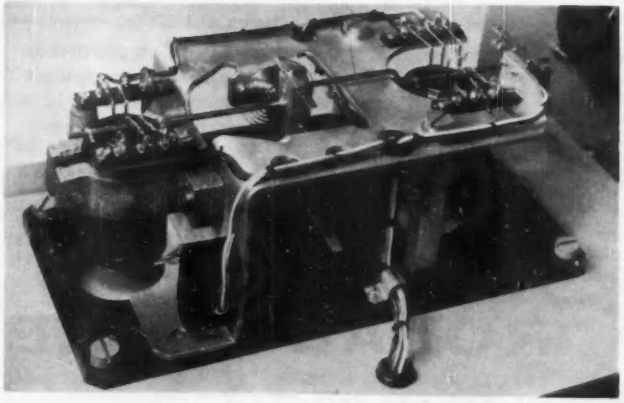
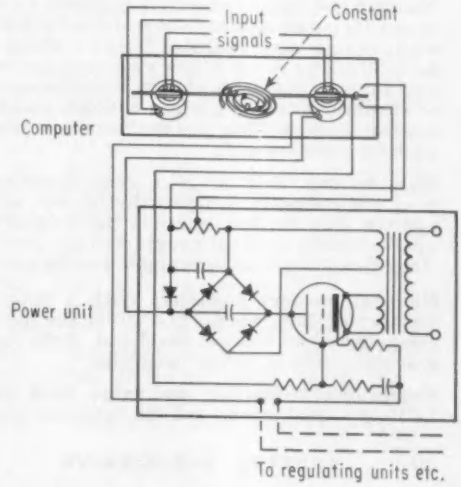


FIG. 3. Contacts on balance beam bias electron tube in power unit to re-center beam between contacts.





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troller. The measured-value signal from the master flow transmitter is looped through the controller to all the computers in series.

The computers provide a dc milliampere output for the desired value of the controllers in a strict ratio to the measured-value signal received from the master flow transmitter. This ratio can be adjusted manually by the ganged potentiometers R2-R5 shown on the schematic diagram.

The computer

The simple computer, Figure 2, uses a moving-coil force-balance mechanism. Coils are fitted to either end of a balanced beam pivoted at the center, and both coils move in the fields of pot magnets, the left-hand one (in Figure 1) receiving the 0-15-ma dc measured-value signal. A change in this signal unbalances the pivoted beam, which carries a small contact, working between a pair of leaf contacts. This center contact is connected to the grid of a vacuum tube and the two outer contacts to sources of grid potential, see Figure 3, so that when one outer contact is closed by unbalance of the beam, the tube plate current increases. Closing the other contact by unbalancing the beam in the opposite direction reduces plate current.

The pot magnet coil is connected in series with the tube, so that the pot magnet field changes in the direction to balance the moving coil and recenter the contacts. The beam is stabilized at the balanced condition by a large capacitor in the grid-cathode circuit of the tube.

All the windings on each computer coil are the same so that the potentiometer shunt and fixed shunt resistors provide the ratio range on each flow line. The maximum ratio setting required is first decided and the fixed resistor calculated, assuming the terminal resistance of the computer windings is the same, $R3 = R6$. The ratio range then becomes:

$$\frac{\text{Max sub flow}}{\text{Max master flow}} : 1 : \frac{\text{Min sub flow}}{\text{Min master flow}}$$

A formula to evaluate R_1 for any ratio can then be derived. Taking the maximum ratio K as greater than 1,

$$R_1 = -(1-K)(R_2+R_3) \pm \sqrt{\frac{[(1-K)(R_2+R_3)]^2 - 4(1-K)(R_2+R_3)}{2(1-K)}}$$

The maximum ratio can be altered easily at a later date by substituting fixed resistors R_1 and R_4 in each computer. The formula gives the value of the fixed resistor for any desired maximum ratio. The variable resistors R_2 and R_3 comprise two linear-wound potentiometers ganged so that when the ratio is greater than 1 at maximum ratio, R_2 is at maximum when R_3 is at zero. A ratio of at least 8:1 is possible.

The output from each computer is then the desired value of each sub-master flow controller. Thus, any change in measured value of the master-flow transmitter affects not only the valve and valve positioner on the master flow line, but also the balance of all the computers. The set-point signal to each sub-master controller therefore changes, and the ratios are maintained regardless of changes in master flow.

The error relays in the circuit of Figure 1 are meter relays that operate audible and visible alarms if the error in any of the controllers exceeds upper or lower limits set on the meters. A switch in each error circuit makes it inoperative if the system is switched to manual control.

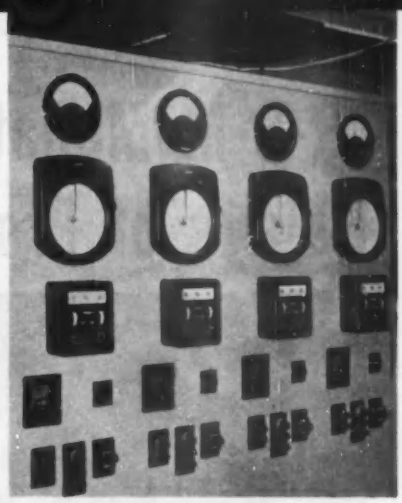


FIG. 4. Control panel of the Imperial Oil Refinery, Halifax, with the computers and ratio setting controls mounted beneath the chart recorders.

Cam Valve Regulates Precision Pressure

DAVID D. CHERRY
JAMES F. MELTON
KENNETH A. McQUEENEY
Alto Scientific Co., Inc.

Servo-driven to null a reference transducer, a cam valve proportions positive and negative pressure supplies to produce precision pressures for testing airborne computers.

Many of the latest aircraft carry analog computers that continuously calculate angle of attack from air pressure data measured by a pitot tube. Accurate ground testing of these air data computers requires equipment that can generate a wide range of accurately-known air pressures.

A computer test set has been built that applies known pressures to the transducers on an aircraft, and provides a set of precision voltages against which the computer outputs can be checked. Another set of precision voltages represents correct outputs for the aircraft's transducers. This permits any errors to be isolated.

Various sets of inputs (air pressure and electrical) are included in the test set, and these are applied to the computer sequentially by an automatic programmer. Thus, the computer is tested at ten discrete points in its altitude speed operating range.

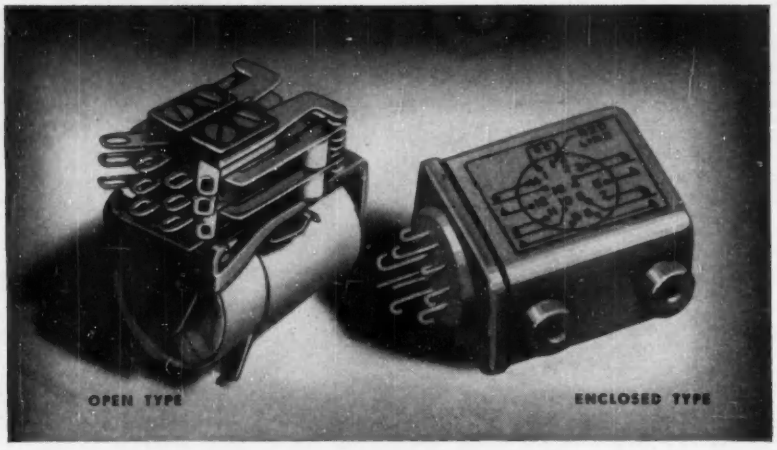
Essentially, the pressure generator unit must generate and maintain two separate output pressures within the range of 3.5 to 50 in. Hg absolute to an accuracy of plus or minus 0.1 mm.

Various schemes were investigated for establishing known pressure references to the accuracies required and for changing and maintaining the output pressures. The one which proved to be the most promising was included in the final design and is shown in the diagram of Figure 1.

The system for producing and maintaining the output pressure uses two pumps, a mixing valve, a pressure transducer which acts as the pressure reference, a servo amplifier, and a servomotor which controls the position of the valve rotor and thus the output pressure.

Pump A forces air into the valve

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APPLICATION: R-B-M Miniature Multipole Relays are used where the prime factors in switching electronic circuits are small size, light weight and reliability. These proven designs are produced for switching low power circuits, low capacitance circuits and power circuits. 125° C insulation now available on some versions. Coils can also be designed for plate circuit.

CONSTRUCTION:

Magnet Frame—Four sizes available on open type relays and three sizes on hermetically sealed type.

Contacts—Cross-bar palladium welded to nickel silver springs or button contacts on Beryllium copper springs.

Terminals and Mountings—Glass headers provided with either solder or plug-in type terminals with many various types of mountings available. Octal type plug-in headers can be provided on the HL enclosure. Plug-in terminals to fit either 9 or 14 pin standard sockets. Maximum of 14 pins for solder connections.

TYPICAL SPECIFICATIONS*

Open	Maximum Coil Resistance (OHMS)	Minimum Power Requirements Per pole at 25° C (WATTS)	Maximum Contact Form With rated current at 32 V.D.C. or 115 V.A.C. (non-inductive load)	Maximum Coil Watts	Enclosed
SM	9,000	.2	4 PDT 5 Amps. or 3 Amps. 6 PST 3 Amps.	3.75	HSM
SMD-2	9,000	1.0	SPNO Parallel Contacts Make 80 Amps. Break 20 Amps. at 32 V.D.C.	3.75	HSMD-2
SC	18,500	.16	4 PDT 5 Amps. or 3 Amps. 6 PST 3 Amps.	4.5	HPSC
SA	18,500	.14	4 PDT 5 Amps. or 3 Amps. 6 PST 3 Amps.	4.5	HLSA
SM-RF	9,000	.2	SPNO, SPDT, DPNC, SPNC, DPNO	3.75	HSM-RF HLSM-RF
SAD-2	18,500	1.0	SPNO Parallel Contacts. Make 80 Amps. Break 20 Amps. at 32 V.D.C.	4.5	HLSAD-2

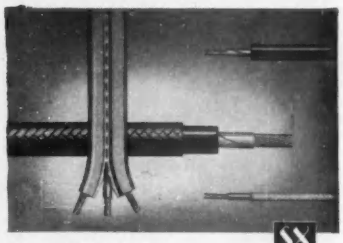
*Other ratings and specifications available.

For additional information write for Bulletin No. 1050

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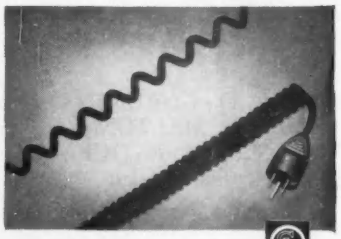
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and pump *B* exhausts air from the valve. The output range of the valve depends mainly upon the capacities of the pumps and the output flow rate. With the pumps used in the final design the output pressure range is 3.5 to 55 in. Hg absolute, with a sufficient flow rate for the estimated aircraft and computer pressure-time leakage.

The valve has an eccentric cam for a rotor, and a housing containing three ports, two inputs and one output. By rotating the cam, the area of the two input ports can be varied, thus mixing the low pressure and high pressure inputs. A resultant pressure between the two extremes (3.5 in. Hg to 55 in. Hg) can be obtained.

The output of the mixer valve goes to a pressure transducer which acts as a pressure reference. The transducer is constructed so that the output voltage is zero at the reference pressure, and increases in a linear fashion on either side of it. The accuracy of the transducer calibration is better than plus or minus 0.1 mm Hg absolute. Thus, since the overall accuracy of the system is determined mainly by the transducer, the resulting system accuracy at the output of the unit is approximately plus or minus 0.1 mm Hg.

The transducer is a twisted torsion-type bourdon tube with one end connected to the armature of a four-pole magnetic-reluctance type pick-off. Figure 2 shows a disassembled transducer. The tube twists an amount proportional to the static pressure introduced into the chamber, and the electrical pick-off can sense motion in the order of 10×10^{-6} in. The result is a relatively high change in electrical output for a small change in input pressure. The transducer is calibrated by positioning the reluctance pick-off for zero output while a laboratory-produced pressure is applied to the bourdon tube.

The final pressure system is indicated in the block diagram, Figure 3. The output of the transducer is filtered to reduce the third harmonic output content, fed to a servo amplifier, and thence to a servomotor. The geared-down output of the servomotor controls the angular position of the valve. Thus, if the output pressure is other than the reference pressure, there will be an electrical output from the transducer which will cause the servo system to change the valve rotor position and bring the output pressure back to the reference value.

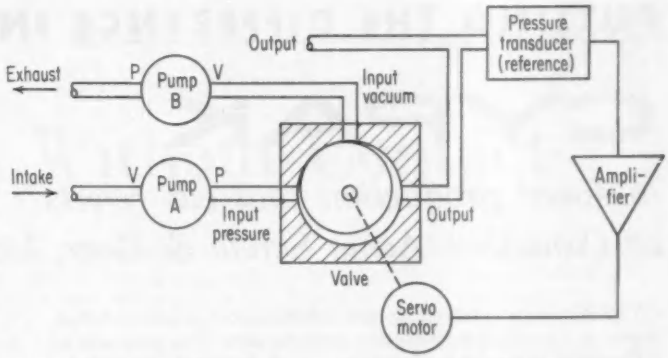


FIG. 1. Servo-operated cam acts as potentiometer between positive and negative pressure sources. Reference transducer is calibrated to give zero output at output pressure desired.

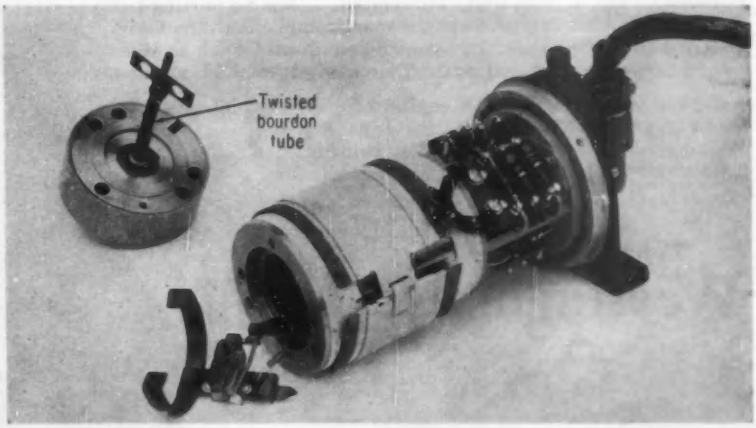


FIG. 2. Pressure reference transducer uses reluctance pick-off that can be positioned to null for any input pressure over wide range.

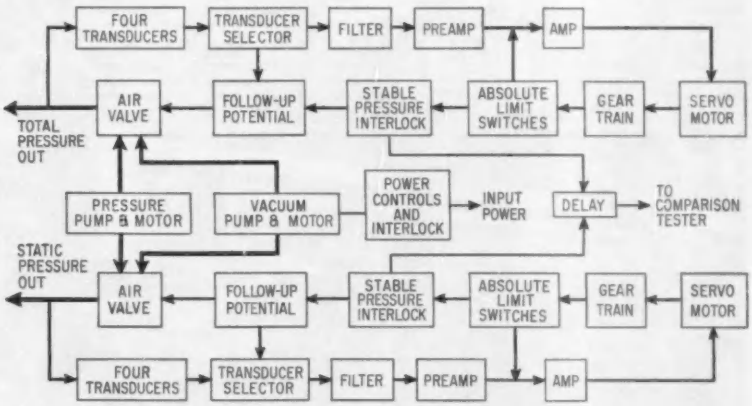


FIG. 3. Pressure generator for computer tester is interlocked to prevent comparing tester and computer outputs if pressure is not stable.

Since two separate outputs are required, two systems, similar to Figure 1 except for the common pumps, are used. Because separate static and total pressures are needed for each of four test conditions, there are eight transducers for maximum accuracy.

To prevent testing the computer outputs while the pressure generator servo system is still correcting the output pressure, a mechanism for detecting rotation of the servomotor is incorporated and operates an interlock circuit in the comparison tester.

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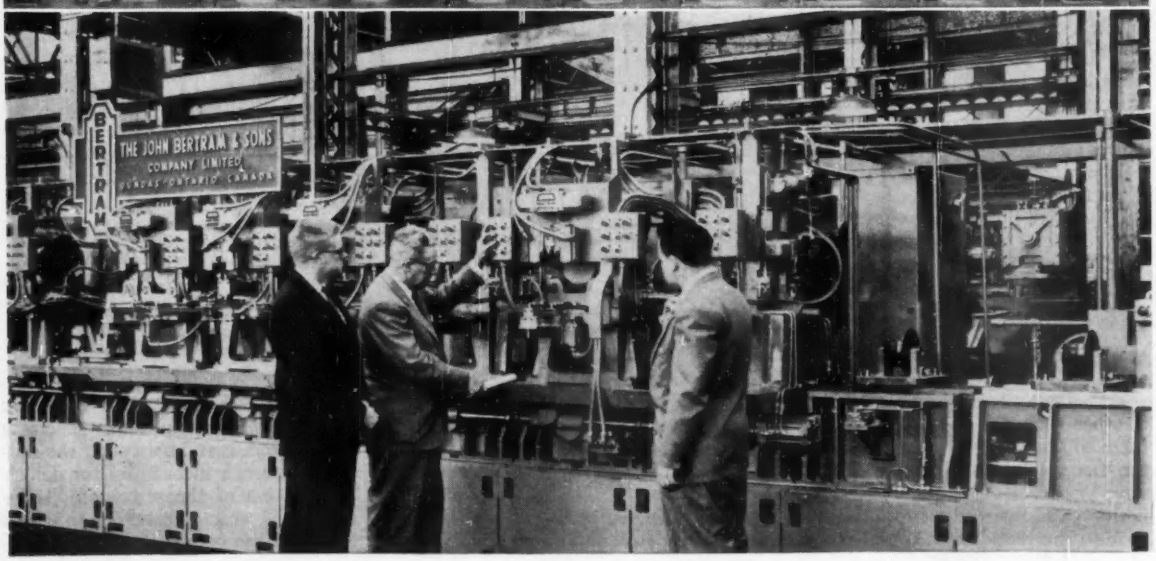
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Meter Relays Without Contacts

S. M. BILLINGS
H. A. HARRIMAN
General Electric Co.

Meter relays usually have electrical contacts carried by the instrument pointer. Such contacts are troubled by contact-resistance variations, because their low current-carry capabilities usually require that they be used ahead of a relay or electronic amplifier.

A new meter relay has been developed which does not use contacts. Instead, the pointer acts as a vane that changes the impedance of a coil in a high-frequency oscillator circuit. The new instrument is shown in Figure 1.

The sensing coils are mounted on the set-point arms, and have no effect on the meter reading. Almost any long-scale switchboard instrument, new or already in service, can be converted into a control instrument by adding these set-point arms. One arm can be used as a low limit or as a high limit, or two arms can be used to control both high and low limits. The limitation is that the two set-point arms cannot be brought closer together than about 20 mechanical degrees.

In Figure 2, *L*1 represents the main oscillator coil. *L*2 and *L*3 are the coils mounted in the instrument, one above and one below the other. All these coils are in the grid circuit of the first part of tube V1 which compose the oscillator circuit. The components are so arranged in this oscillator circuit that it oscillates only when the vane is in the air gap between *L*2 and *L*3.

The second half of tube V1 is in the relay circuit *RY*1. The current through the relay coil *RY*1 is controlled by the bias on this tube. The bias for this tube comes from the voltage developed across terminals 6 and 7 of transformer *T*1, and the voltage drops across *R*9. The voltage across 6 and 7 of the transformer is constant, but the voltage drop across *R*9 is determined by whether the first part of V1, the oscillator, is oscillating or not. When the vane is out of the coil, the tube stops oscillating and the current drawn through *R*9 is large; therefore, the voltage drop across it is large, just about equaling that of the voltage across 6 and 7 of the transformer. Since it is of the opposite polarity, there is about zero bias on the second half of V1, causing sufficient current to flow to energize *RY*1.

When the vane enters the coil, the circuit goes into oscillation and the current through *R*9 drops appreciably. This allows nearly the full value of the voltage between 6 and 7 of the transformer to be applied as grid bias on the second part of tube V1, thus reducing the current through *RY*1 and de-energizing it.

With the vane out of the coil, *RY*1 is energized and so is *RY*2. Then as the vane enters the coil and the circuit goes into oscillation, *RY*1 is de-energized and so is *RY*2. With both normally-open and normally-closed contacts on *RY*2, any type of external control can be made from this arrangement. Further, any failure in components or even in the power line will cause the unit to fail safe with the output relay *RY*2 de-energized.

The circuits of Figure 2 are housed in a separate plug-in unit that is connected to the instrument by a 3-ft shielded cable. Connections to the control contacts are made on the plug-in units. Two electronic relay units are needed for high and low limit control.

Limitations

There are two major limitations that should be considered:

- Instruments normally have a small amount of overshoot when subjected to a step change; hence, the output relay may trip on transients even though the steady-state instrument indication is not at the set-point level.
- The set-point arms act as a pointer stop; hence, readings beyond the set-point are not available, but the relay will be tripped to indicate control actions for signals that drive the instrument pointer beyond the set-point.

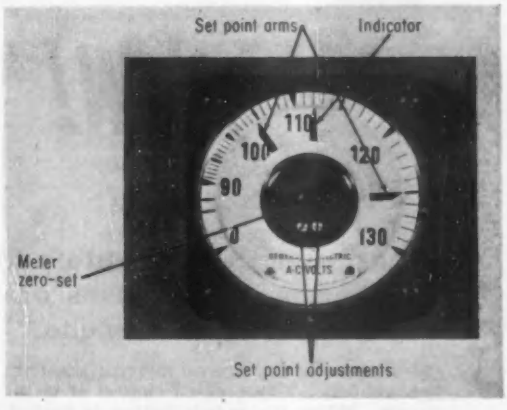


FIG. 1. Set-point arms can be added to almost any switchboard instrument; they carry sensing coils.

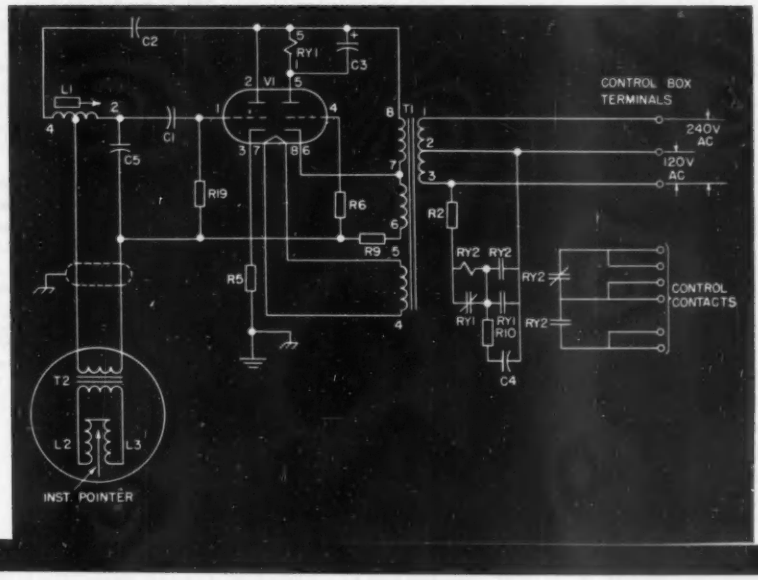


FIG. 2. Electronic relay unit required for operation of contactless meter relay.

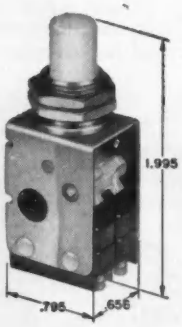
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NEW!

MICRO SWITCH alternate action pushbutton switch gives on-off control of up to four circuits

Shown here is the MICRO SWITCH 82PB1-T2 (unlighted) which allows on-off control of up to four circuits. When the switch button is pushed, the contacts of the switches are alternately reversed. They complete a cycle of action every two operations of the button.

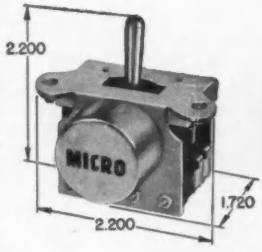
This alternate action is achieved by the extremely compact design of a long-life assembly of ratchets. Variations are possible which will permit almost any sequence of switch operation. For instance, on a switch with a four-push sequence, a great many sequences of switch operation can be provided.

This switch requires but 1⅜ in. below its mounting panel and mounts in a ½ in. hole. Button is of off-white plastic. Operating force is 35 oz. max.

(Send for Data Sheet 124)

SWITCH CHARACTERISTICS

Two SPDT switches; break distance .010 in. min. Electrical data: U/L listed at 5 amps. 125 or 250 vac; 30 vdc rating: inductive, 3 amps. at sea level and 2.5 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet. Maximum inrush is 15 amps.



NEW!

MICRO SWITCH magnetic hold-in toggle switch—permits remote release of toggle lever to its un-operated position

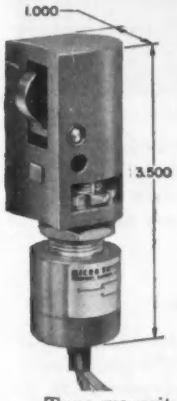
This MICRO SWITCH 2ET1 magnetic hold-in toggle switch is a momentary-action toggle switch which also functions as a maintained-contact switch by means of a solenoid incorporated into the design of the switch. When the toggle lever is operated and the solenoid is energized, the magnetic force of the solenoid holds the switch in the operated position. This magnetic hold-in feature permits remote electrical release of the lever.

The precision SPDT switch and a 28 vdc solenoid are contained in one compact unit. The small size makes it an ideal component for applications where space is a critical factor. *(Send for Data Sheet 137)*

SWITCH CHARACTERISTICS

Total travel 30°; Electrical data: 28 vdc rating: inductive 3 amps. at sea level and 2.5 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet; Hold-in rating of solenoid is 18-30 vdc.

Switches have uses unlimited



NEW!

MICRO SWITCH "Rocket Switch"— a rugged, sealed small switch for indicating and lockout devices

Developed for use on rocket launchers, this MICRO SWITCH 21AS2 assembly fits the needs of many industrial designs.

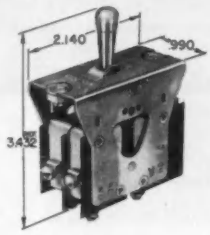
The assembly consists of one SPDT Type-EN switch attached to a rugged cam-type actuator. The assembly is environment-proof and withstands the highly-corrosive effects of rocket propulsion gases. The assembly will withstand heavy impact hammer blows on the actuator.

(Send for Data Sheet 120)

SWITCH CHARACTERISTICS

Operating force—6 to 12 lbs. Full overtravel force—10 lbs. min.; Release force—4 lbs. min.

Electrical Data: 28 vdc rating: inductive, 3 amps. at sea level and 2 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet. Motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet. (Altitude ratings established with seal deliberately broken.)



NEW!

MICRO SWITCH three-position toggle switch—4 SPDT circuits with a single lever

MICRO SWITCH 115AT Series of toggle switches uses four SPDT switching units. Two units are actuated in each extreme toggle lever position. None are actuated when lever is in center position.

Many different combinations, however, may be obtained, including the make and break of circuits in all three lever positions.

Outstanding features of this series include the compact design, positively-driven switch actuators and sturdy construction. A safety catch guards against accidental movement of toggle lever. *(Send for Data Sheet 132)*

SWITCH CHARACTERISTICS

Electrical rating at 30 vdc: inductive—10 amps. at sea level, 6 amps. at 50,000 ft.; resistive—10 amps.; motor—6 amps. Basic units listed by Underwriters' Laboratories for: 10 amps. 125 or 250 vac; ½ amp. 125 vdc; ¼ amp. 250 vdc.



NEW!

MICRO SWITCH completely sealed magnetic hold-in toggle switch

The MICRO SWITCH 5ET Series is a completely sealed momentary action toggle switch which also functions as a maintained contact switch. When the toggle lever is operated and a solenoid is energized, the magnetic force holds the lever operated. This hold-in feature permits remote electrical release of the lever.

Both switch and solenoid are sealed within the cylindrically shaped enclosure. This insures constant operating characteristics. An elastomer seal at the base of the toggle lever prevents entrance of dust or moisture. *(Send for Data Sheet 121)*

SWITCH CHARACTERISTICS

Total travel 30°; Contact arrangement SPDT, may be wired either N. O. or N. C. Electrical rating at 28 vdc: inductive, 3 amps. at sea level and 2.5 amps. at 50,000 feet; resistive, 4 amps. at sea level and 50,000 feet; motor, 4 amps. at sea level and 50,000 feet; inrush, 24 amps. at sea level and 50,000 feet; Hold-in rating of solenoid is 18-30 volts dc.



NEW!

MICRO SWITCH "typewriter" pushbutton switch for manual keyboard control

MICRO SWITCH 1PB81-T2 switch is ideal for one-finger rapid-repeat operation such as is required for the type of keyboard control found in electric typewriters, adding machines, etc. The repeat action is as rapid as the fastest operator can push the button.

This switch uses a SPDT MICRO SWITCH subminiature switch for snap-action reliability. The contoured button and unique overtravel spring combine to reduce operator fatigue. Operating "feel," however, is sufficient to avoid mistakes and false actuations.

Removable ½ in. dia. plastic button is available in red, green, off-white or black. It is keyed to prevent rotation. *(Send for Data Sheet 125)*

SWITCH CHARACTERISTICS

Electrical rating at 30 vdc: inductive—3 amps. at sea level and 50,000 ft.; maximum inrush—15 amps. Basic subminiature switch is listed by Underwriters' Laboratories at 5 amps. 125 or 250 vac.

MICRO SWITCH

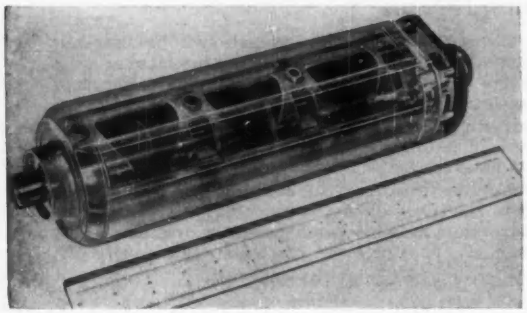
A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

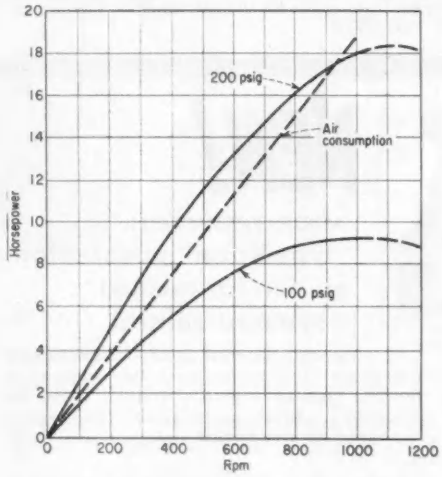
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NEW PRODUCTS

LISTING IN GROUPS

Designs of the Month
Research & Development
Measurement & Data Transmission
Information Display Instruments
Control Devices
Power Supplies
Final Control Elements
Component Parts
Accessories & Materials





NEW AIR MOTOR has near linear output.

Pictured is a new cam-piston air motor, covered with a clear plastic to illustrate its internal construction. The gearless unit is said to be capable of operating on hot compressed air at temperatures of over 1,000 deg F with no conventional lubrication or cooling. It is currently being produced in three sizes, varying in overall length from 9 to 13 in. Features include fast acceleration with quick reversibility, maximum horsepower-to-weight ratio, and design flexibility. Acceleration time of the motor is less than 0.05 sec in most applications, with high starting torque. Depending on the pressure supply available, outputs of from 1 to 300 hp are possible.

When coupled with a ball screw, which may retract within the full length of the motor shaft, the unit can serve as a compact, high performance, linear actuator in high-temperature pneumatic power-control systems. Applications include the actuation of thrust reversers, control surfaces, etc.

Operation is as follows: a force resulting from a pressure differential across the piston is exerted in an axial direction. Because of the stationary position of three equally-spaced cam-follower bearings, the piston is forced to rotate through 60 deg on each power stroke. Since the piston is ball-splined to the output shaft, a resultant torque is transmitted. At the end of the stroke, the pressure differential is reversed, providing a double-acting piston which reciprocates three times per revolution. Low operating speeds of from 100 to 2,500 rpm eliminate the need for gear reduction in many applications, and minimize problems of excessive wear, high rotational stresses, and overspeed control. The graph at the left shows some of the characteristic curves.—AiResearch Mfg. Div. of the Garrett Corp., Phoenix, Ariz.

Circle No. 1 on reply card



PHASE-SENSITIVE DETECTOR features plug-in design.

The Model IC-101 phase-sensitive detector is a linear demodulator designed for high-performance servo systems. This particular model, used for demodulating 400-cps carrier signals, has an input signal range of 0.025 to 15 volts rms. Output ripple is below 10 mv while output impedance is 700 ohms. The unit measures approximately 5 in. by 3 in. by 2 in. and weighs 15 oz. Two controls are provided: a null, to balance out ripple at zero signal input, and a zero adjustment for the output signal. Linearity is within 1 percent, and input impedance is 50,000 ohms. Quadrature rejection exceeds 20 db. Significant areas of application include recording instrumentation, servomechanisms, null indication, and encoding.—The Emerson Electric Mfg. Co., Saint Louis, Mo.

Circle No. 2 on reply card

NETWORK ANALYZER sells for about $8,000.

Said to eliminate many hours of sliderule and hand calculation, and to offer advantages hitherto obtainable only from larger analyzers, this new miniaturized ac network analyzer uses a patchcord system to simulate power transmission networks and generating stations of a large utility company. By compressing miles of transmission lines to fit on an ordinary desk, the analyzer provides a convenient tool to determine the feasibility of additional loads, additional lines, and/or additional generating stations, and their optimum locations. Designed to sell for around $8,000, the unit takes a 115-volt supply and consumes about 300 watts. No external cooling is required through all normal ranges of temperature and humidity.—General Electric Co., Phoenix, Ariz.

Circle No. 3 on reply card



DESKSIDE COMPUTER checks own reliability.

The IBM 610 Auto-Point Computer, a mobile, general-purpose digital unit with the logical and arithmetic facilities normally found only in large-scale machines, is said to be able to handle problems ranging from insurance premium computations to jet aircraft design. Principle features of the new unit include automatic decimal point control, simultaneous programming, single-key instructions, and automatic built-in checks for reliability. Adding and subtracting operations can be performed at the rate of about 214 per minute. Average multiplication takes about 1.37 sec, division about 1.43 sec, and square-root extraction about 2.23 sec. An 8-in. magnetic-drum memory provides 84 locations or registers.—International Business Machine Corp., New York, N. Y.

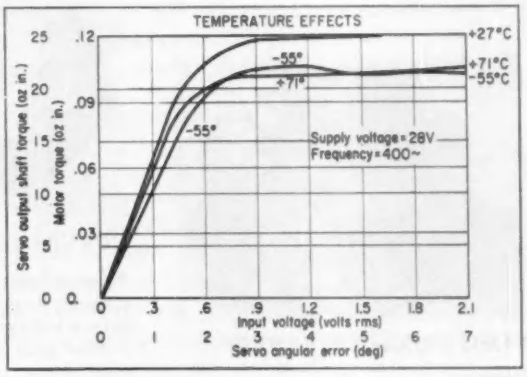
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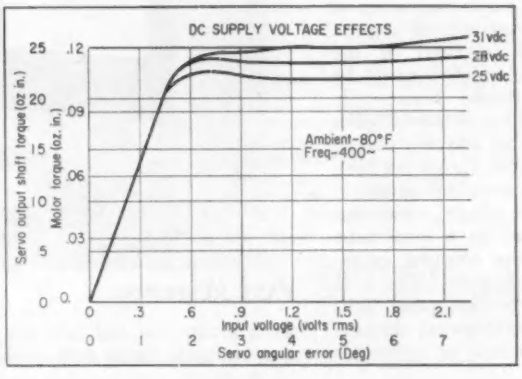


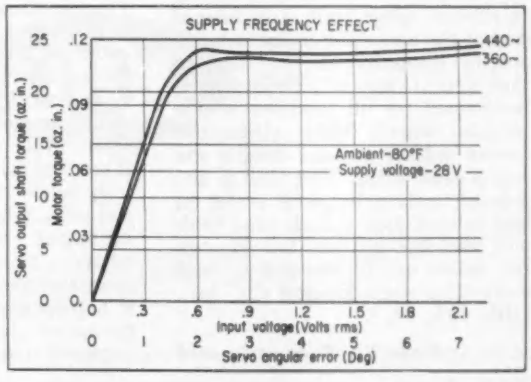
SERVO REPEATER develops 21 oz-in. of torque.

Weighing just 12 oz, and measuring 2 in. in diam and 4 in. long, this new servo repeater is a completely self-contained circuit element. Included are a transistorized servo amplifier, motor, synchro, power supply, and gear train. Without using external components, the new unit will repeat information obtained from synchro transmitters. It will provide suitable power for instrument-type servo applications, but not excessive power. It operates on 115-volt, 400-cycle supply and develops 21 oz-in. of torque at the output shaft at a velocity constant of 60/sec. Static accuracy is said to be within 1/10 deg. Curves right and below show the performance of the system for variations in temperature, voltage, and frequency.—Waldorf Instrument Co., Huntington Station, N. Y.

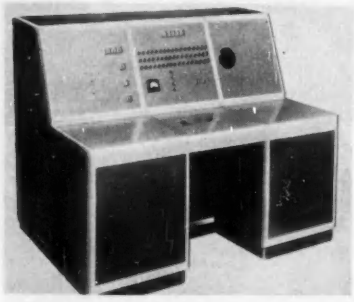
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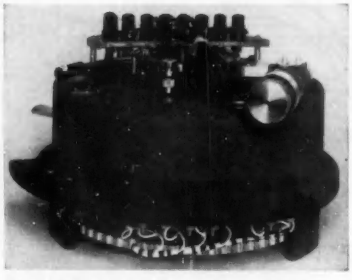
RESEARCH, TEST & DEVELOPMENT



TUBE ANALYZER

The Rheem REL-1001 is an automatic production and laboratory tube analyzer, said to provide faster, more accurate, and simpler operation testing and analysis of electron tubes. The unit's 17 test positions can be set up for any combination of 19 tests. Operation is automatic, semi-automatic, or manual.–Rheem Mfg. Co., Rivera, Calif.

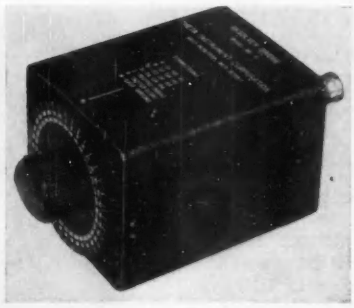
Circle No. 6 on reply card



5-DEG PRECISION BRIDGE

Pictured is one of two new index stands equipped with either a synchro or resolver bridge built as an integral part of the unit. The bridge is mechanically connected to the stand so that correct angular relationship is maintained for all positions of the indexing wheel. Maker claims this feature reduces operator fatigue and and possible error. Test time is also reduced, making the units useful for high volume testing. Each stand holds only one size synchro, but adapters and collets can be changed to hold many other sizes.–Kearfott Co., Inc., Little Falls, N. J.

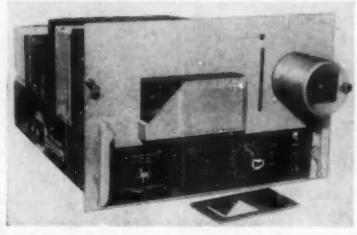
Circle No. 7 on reply card



MAINTAINS ACCURACY

Intended for use in synchro, resolver, and servo-system measurements, this panel-mounted instrument can determine an angle with an angular error of less than 10 sec of arc. Each unit is calibrated at the frequency of operation and maintains its accuracy because of a passive construction. Housed in an aluminum casting, the unit will withstand shock, vibration, sand, dust, and salt spray tests even though it is a primary measuring tool. Dial diameter on the unit is 4 in. Resistance of each arm is 10,000 ohms.–Theta Instrument Corp., East Paterson, N. J.

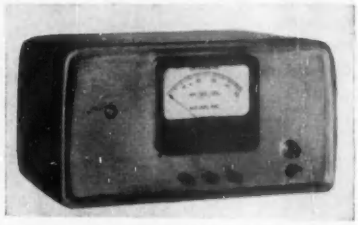
Circle No. 8 on reply card



CURVES TO VOLTAGES

Nonmechanical, this new instrument converts a curve drawn on graph paper into a voltage to be used to program radiant heat test loads, and in other control or computing applications. The all-electronic unit, called the Program Scanner, operates when a photographic transparency of a given curve is inserted in front of the "flying spot" tube which is swept by a vertical line moved horizontally across its face. The photomultiplier circuit in the scanner acts as a switch; it sees the flying spot during the time it is below the curve and turns on and off a Schmidt trigger, which has its output clamped to a glow tube reference to produce constant amplitude, variable width pules. The unit is not hampered by the speed limitations of electromechanical devices. Accessory items include an automatic camera to facilitate making of transparencies, and time base generators to drive the horizontal sweep.–Spar Engineering & Development Co., Wyncote, Pa.

Circle No. 9 on reply card



RATE-OF-CHANGE INDICATOR

The Deltameter, an indicating instrument that measures precise voltage rates of change, is now commercially available. The unit's output signal, representing millivolts per sec^n, can be visually displayed on a calibrated meter, or fed into a recorder or control system. Input voltages may represent pressure, temperature, pH, light intensity, velocity, contact potential, etc. In operation, the unit samples a voltage pulse at some time, t, and stores it. At time $t + \Delta t$, a second sample is recorded and compared to the first. The time interval between samples is controlled by the instrument. Output is dE/dt, indicated directly on the meter scale. Originally developed for checking precession and drift rates of gyros, the device has application potential in installations involving atomic reactors, metallurgical processes, computers, food processing, instrument testing, and many other areas.–Miljan, Inc., Paramount, Calif.

Circle No. 10 on reply card



FAST RESPONSE

Both production and laboratory tests can be made faster and more accu-

A FRESH APPROACH TO CLOSE TOLERANCE NEEDS



FEATURES

• Now available in 5 wattage ratings • Metallic resistive film accurately controlled and applied to special high quality ceramic cores • Designed to surpass characteristic A of specification MIL-R-10509B • Low noise level independent of range • Voltage coefficient can be disregarded

Here are molded metal film resistors that set new standards of performance—units that will withstand full load at 125° C. ambient to zero at 175° C.* In addition to high initial accuracy, these new MIL type units combine a stability on load and a low, controlled temperature coefficient never before available in film resistors. They also provide low inductance and shunt capacitance plus excellent high frequency characteristics.

Small in size and weight, IRC precision metal film resistors can replace precision wire wound resistors in many applications. They are available in five temperature coefficient spans for maintaining or controlling resistance over wide temperature ranges. They can be used where high stability must be obtained under difficult load and humidity conditions. You'll also want to investigate them for high frequency applications. Send for complete details.

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Low Wattage Wire Wounds • Resistance Strips and Discs • Selenium Rectifiers and Diodes • Hermetic Sealing Terminals • Insulated Chokes • Precision Wire Wounds • Potentiometers

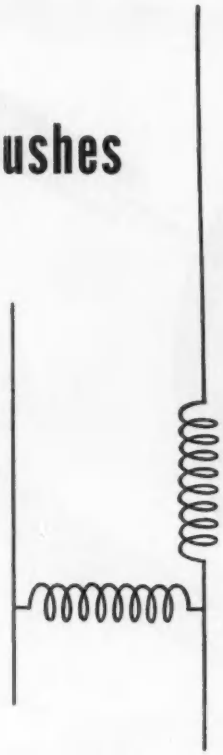
IRC

*Except 2 watt size which is rated full load at 100°C. ambient.

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Because it is an induction regulator, the Inductrol maintains ±1% a-c output voltage *without using brushes.*

This means radically lower maintenance costs than are possible with old brush-commutator type regulators. There are no brush inspection, cleaning, replacing, or stocking problems. There are no commutators to arc over or wear down. General Electric Inductrols mean precise, highly reliable, economical voltage regulation.

For more information, write Section 425-7, General Electric Co., Schenectady 5, N.Y., or contact your nearest General Electric sales office or agent.

*General Electric Trademark for induction voltage regulators.

Progress Is Our Most Important Product

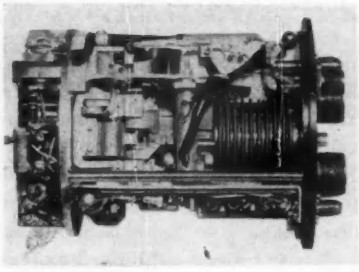
GENERAL ELECTRIC

NEW PRODUCTS

rately with the new Model 510 Megohmmeter. It measures six decades of resistance on a single 6-in. mirror scale and has five to 10 times faster response than conventional ohmmeters. Typical uses are: rapid checking of insulation resistance of motor windings, capacitors, transformers, and cables; and measurement of surface and volume resistivity in insulating compounds. With its 5-, 50-, and 500-volt test potentials, the instrument provides a selection of safe voltages for measuring all test samples and for checking voltage coefficients. Features include range-switching elimination, a linear scale with no compression at the high end, negligible drift, simple operation controls, and a guarded, completely shielded input.—Keithley Instruments, Cleveland, Ohio.

Circle No. 11 on reply card

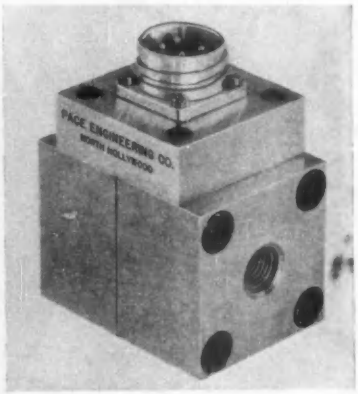
MEASUREMENT & DATA TRANSMISSION



NEW MACH METER

This photo shows the compact internal construction of a new lightweight, pressure-actuated Mach meter that responds to changes in static pressure, pitot pressure, and stagnation temperature. Using mechanical relationship of forces produced by pitot and static bellows and their resultant on a floating junction gives a high order of sensitivity. Through a servo system, the unit also provides a high power level for generating output functions of Mach number and, in combination with stagnation temperature, true air speed. Outputs can be provided for direct and remote reading instruments in a variety of forms for digital or analog computers. Standard units are designed to operate at altitudes up to 60,000 ft over a variety of speed ranges.—M. Ten Bosch, Inc., Pleasantville, N. Y.

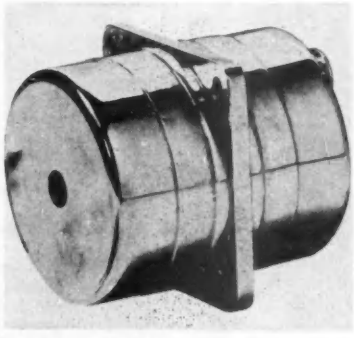
Circle No. 12 on reply card



OVERLOAD PROTECTED

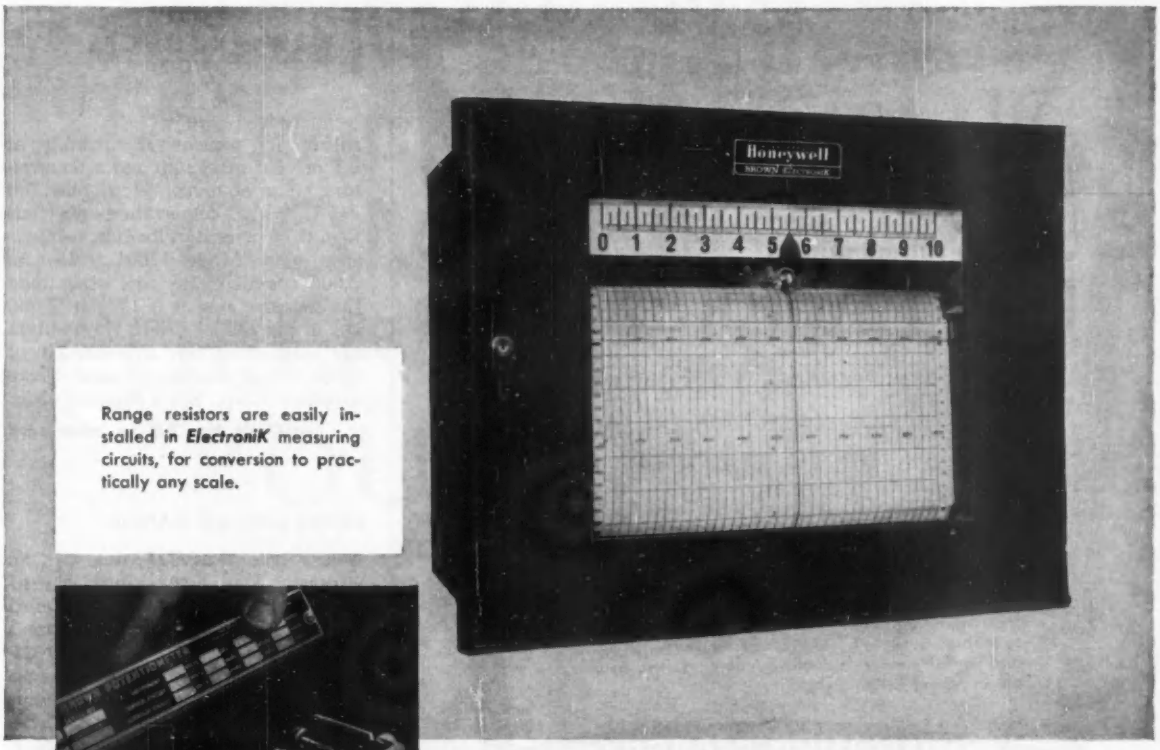
A new magnetic reluctance-type pressure transducer, the Model P3D measures low differential pressures at line pressures up to 5,000 psi. Offered in full-scale ranges from 3 in. water to 500 psi differential, the new units are capable of measuring accuracies to within 1 percent of full scale. The Model P3D may be used with any system that is compatible with inductance-ratio input devices. Features include symmetrical stainless steel construction, low-pressure chamber volume, and positive overload protection in both directions. Unit weighs 2 lb, is about 1⅞ in. sq and 2¼ in. long.—Pace Engineering Co., North Hollywood, Calif.

Circle No. 13 on reply card



HIGH OUTPUT

This new fluid-damped linear accelerometer, featuring high-output voltage, is now available on a production basis. Internal design of the unit reduces hysteresis to a negligible factor. Models 12001 and 12002 (latter shown above) have a linearity



Range resistors are easily installed in ***ElectroniK*** measuring circuits, for conversion to practically any scale.

the *ElectroniK* recorder or indicator is a thousand instruments in one

An *ElectroniK* instrument adapts easily to your changing needs, never becomes obsolete. Its remarkable versatility is made possible by the many measuring circuits . . . many types of records or indications . . . many pen or print wheel speeds . . . and the wide variety of functions that can be incorporated in the instrument.

You can convert most *ElectroniK* instruments to practically any scale, simply by soldering appropriate kit-supplied range resistors into the measuring circuits. And you have a choice of more than 575 *standard* charts and scales in strip chart instruments (similar large choice in indicators and circular chart models). You can change chart speeds from one half to four times the basic speed, with a simple gear change.

Use *ElectroniK* instruments to measure temperature, pressure, flow, pH, chemical concentration, voltage, speed—*any* variable that's translatable into a d-c signal.

Unitized construction lets you transfer complete control units from one *ElectroniK* instrument to another. Cases are designed for both surface and flush panelboard mounting. With auxiliary switches, the instrument works in conjunction with audible or visual alarms and safety cutouts.

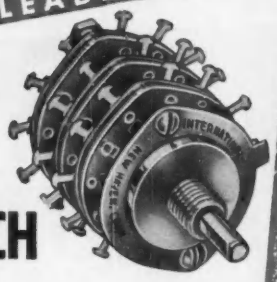
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BROWN INSTRUMENTS
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NEW SERIES 5000 sub-miniature ROTARY SWITCH



NOW PROVIDES 12 CONTACTS ON EACH SIDE OF EACH DECK UP TO 3 DOUBLE DECKS

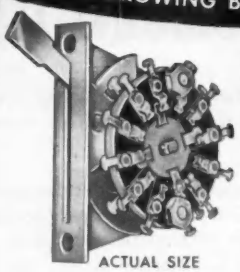
No Increase In Size Over Series 7000

A low-contact resistance switch ideal where small size and peak performance are essential. Available with 1, 2, 3 or 4 poles on each deck and with either shorting or non-shorting contacts. Also available with rotary contact shorting out all positions except one, and all variations to shorting out only two positions. Order a switch today and see for yourself its many advantages. Also available as Spring Return Switch.

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Since 1947, GROWING BIGGER making things smaller



ACTUAL SIZE

sub-miniature SERIES L-5000 LEVER SWITCH

36 POLES with single throw switch

24 POLES with double throw switch

Designed for miniaturized or transistorized test equipment, speech in-put systems, intercoms and remote control panels. Also available as Spring Return Lever Switch.

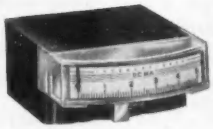
SIDE INDICATORS

For Horizontal or Vertical Mounting

Now Available in 3 SIZES

Models 1145, 1135 and 1120

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1½" Ruggedized Meters • 1" and 1½" Panel Meters • 1½" VU, DB and Illuminated Meters • Miniature Multitesters • Side Indicators

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NEW PRODUCTS

within 1.5 percent, repeatability of 0.5 percent maximum and a temperature range of minus 54 to plus 200 deg C, with a temperature effect less than 0.75 percent. Vibration performance in the Model 12001 is 25 g to 2,000 cps along any axis other than the sensitive axis; it is 15 g to 2,000 cps in the Model 12002. In addition the instrument has a resolution of 0.002 for all ranges.—Physical Measurements Corp., Santa Monica, Calif.

Circle No. 14 on reply card

LONG LINEAR RANGE

A new type of LVDT, one with an unusually long linear range, has recently been made available. Called the 600 XS-AT, the new unit has a low output impedance and a very stable sensitivity-vs.-temperature characteristic. Linear range is plus or minus 0.6 in. from null position of core.—Schaevitz Engineering, Camden, N. J.

Circle No. 15 on reply card

INFORMATION DISPLAY INSTRUMENTS



EASILY SERVICED

A new line of light-weight turbine-type flowmeters is said to be accurate to within 0.5 percent. Materials handled include jet fuel, gasoline, oil, water, and chemicals, over a wide range of temperatures and pressures. Viscosity permitting, temperatures between minus 80 and plus 1,000 deg F can be accommodated along with pressures up to 5,000 psi. The flow indicator shown here is a direct-reading instrument. It can be calibrated in gpm or lb/hr. The instruments are easily disassembled for cleaning and servicing without affecting linearity. Twelve sizes of flowmeters

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The LITTON 20 DIGITAL DIFFERENTIAL ANALYZER is a uniquely personal mathematical tool – which you use yourself at your own desk. The remarkable insight you obtain with this accurate, versatile instrument is an experience reported again and again by mathematicians and engineers. *Insight into the problem* stems partly from your *own* programming, partly from the continuous rapport you have with the problem as the Litton 20 solves.

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Solution of linear and non-linear differential equations including those containing transcendental functions.

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Simulation of non-linear dynamical systems.

Generation of any standard algebraic, trigonometric, or inverse trigonometric functions.

Trajectory problems, including generation of the standard atmosphere.

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Generation of the special functions of mathematical physics which can be expressed as solutions of differential equations. These include the Jacobi Elliptic Functions, Sturm-Liouville Equation, Hypergeometric Function and Legendre Functions.

Multiplication and division of variables.

Coordinate system transformations.

Performance of logical switching functions, such as introduction of step functions, ramp functions, limiting, and mode of operation switching.

CAPACITY: Model 20—20 Digital Integrators
Model 40—40 Digital Integrators

ACCURACY: Up to 1 part in 260,000 (to 5 decimals).

COST: $12,800 & $16,800.

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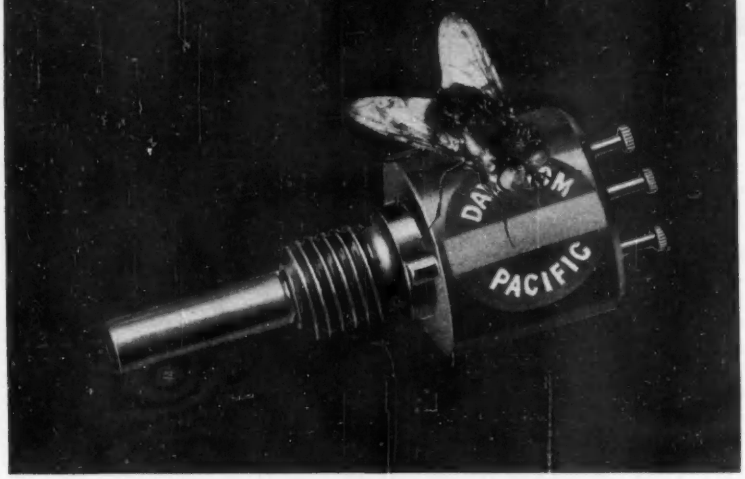
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ELECTRONIC EQUIPMENTS DIVISION
336 North Foothill Road • Beverly Hills, California

LITTON 20 & LITTON 40 DIGITAL DIFFERENTIAL ANALYZER LITTON GRAPH PLOTTER LITTON GRAPH PLOTTER/FOLLOWER
LITTON PAPER TAPE PUNCH/READER LITTON DIGITAL TO ANALOG CONVERTER

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Try the "Flyweight"



YES, try the SERIES 304!

When your available space isn't large enough to hold an active sand flea, but you must have a single turn potentiometer of utmost reliability and linearity, try the **SERIES 304**, a "flyweight" in the ranks of Daystrom precision, wire-wound potentiometers.

Check these outstanding features:

SIZE: 0.5" dia. by 0.375"

LINEARITY: Precision winding techniques give the **SERIES 304** a linearity of from 3% to 0.3% standard, or as good as 0.18% on special order.

RELIABILITY: The exceptionally rugged construction of this potentiometer gives it a service life of not less than 500,000 cycles.

STABILITY: Only materials of low (and similar) temperature coefficients are used in order to produce great stability under all temperatures.

AVAILABLE WITH: Integral shaft lock
Servo or panel mount
Rotational stops

Write **TODAY** for complete details on this and other precision potentiometers from **DAYSTROM PACIFIC POTENTIOMETER DIVISION!**

Openings exist for highly qualified engineers.

DAYSTROM PACIFIC
A division of DAYSTROM INC.
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9320 Lincoln Boulevard Los Angeles 45, California

NEW PRODUCTS

with capacities ranging from 0.25 to 125 gpm are available.–George L. Nankervis Co., Detroit, Mich.

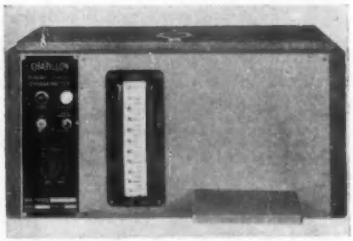
Circle No. 16 on reply card



PRE-CALIBRATED

Accu-Vac capsule dial is the name of a new line of absolute gages, available in the ranges of 0-20 mm, 0-40 mm, and 0-760 mm Hg. Units may be flush-mounted on instrument panels, or directly mounted into the line by use of the threaded or rubber tubing couplings provided with the instrument. Dial face is 4 in. in diameter, and both graduations and figures are large and readable. Prices range from $70 to $80.–Arthur F. Smith Co., Rochester, N. Y.

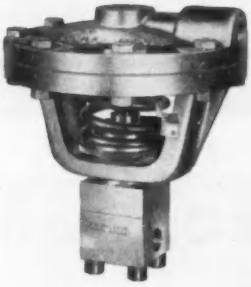
Circle No. 17 on reply card



LOW-POWER TESTER

This new running torque tester is one of the 100RT series, designed to test subfractional hp motors. It has three sets of interchangeable springs and the following capacities: 0.1, 0.5, and 2.0 oz-in. The dial is graduated from 0 to 100 in increments of 1. Accuracy is to within 1 percent of the particular capacity. Heart of the unit is a set of extension springs mounted on a lever, which is connected with a hysteresis brake. A

MINIATURIZATION From Pilot Plant to Process



"BANTAM" 500 SERIES VALVE

Throttling "Bantam" Diaphram Control Valves for all standard control valve uses, Cv of 0.6 and below, up to 1000 psi and 500°F, characterized, renewable trim, 316 stainless steel and Teflon only wetted surfaces, low in hysteresis size and weight, 2000 series "Bantam" Control Valves available for on-off service.



MINIATURE DIAPHRAGM OPERATED SHUT OFF VALVE

Body PVC, diaphragm neoprene, diaphragm head aluminum. Body and operator 2" dia. x 1¾" high. (⅛ or ¼ NPT).

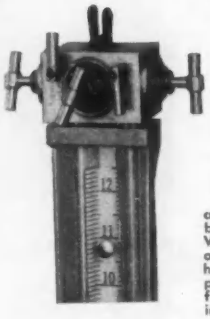
"DEMI" PACKLESS VALVE

For services when packing is a problem, manifolding of small valves in one unit at low cost. For services up to 750 psi and 500°F, screw, toggle, or diaphragm operated, the "DEMI" line is ideal for panel mounting up to five valves in one block.



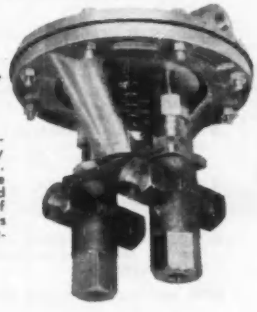
"DEMI 54"

5 Valve Manifold for integral mounting on cleanout type Manometer. Packless design, 2 shut off valves, one bypass valve, 2 vent valves. Other 3 or 5 valve models available with or without special manometer mounting.



WHIFFLETREE OPERATOR

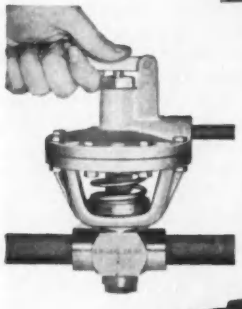
Two valves operated simultaneously by one operator. Valves may be globe or three-way and have a multitude of piping arrangements for mixing and routing applications.



AIR RATE INDICATOR

Top and bottom housing, 1¼" square anodyzed aluminum barstock, combination column studs and gauge protection. The ⅛" IPS ports may be relocated by removing column studs and rotating top or bottom housing. Standard calibration indicates 0 to 2 standard cubic ft. per hour of air. Other models available with built-in toggle actuated packless valves or needle type valves for precise control or special porting or additional ports to suit your requirements.





MANUAL RESET

Wherever control air on dangerout or toxic process flows must be blocked for safety, on air failure until manually reset, these valves insure against disaster. Standard sizes ¼" and ½" I.P.S.



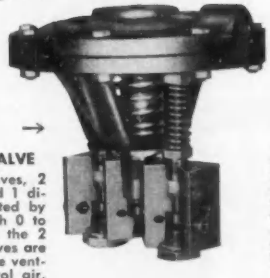
SAUNDERS VALVE, AIR OPERATED

Plastic valve, 2" and below, metal valve 1" and below. G. W. Dahl Co., Diaphragm Operators on these valves provide simple, sure automatic operation. Each application must submit full flow information.

MINIATURE THROTTLING CONTROL VALVE, TOP MOUNTED MOORE POSITIONER

Compact, accurate rugged. High lift, positioning accuracy, low cost, and low in weight and size. Body, bonnet and blind head of barstock construction. Valve sizes up to 1", screwed or flanged. Trim Cv, 12.0 to 0.001. Pressures, 0 to 2000 psi. Temperatures, Minus 400 to Plus 1000°F.



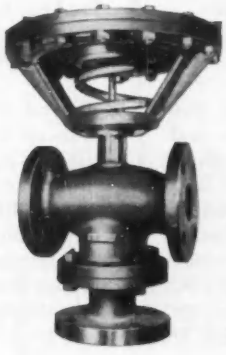


BLOCK VENT VALVE

3 balanced valves, 2 reverse acting and 1 direct acting, actuated by one operator. With 0 to 3 psi control air, the 2 reverse acting valves are closed, center valve vented. At 6 psi control air, all valves closed. At 12 to 15 psi, the 2 reverse acting valves are open and the vent valve is closed, allowing free flow through body. Design pressure 1000 psi. Teflon, Chevron packing. Teflon seating for tight shut off.

DIAPHRAGM OPERATED 3-WAY CONTROL VALVE

Aluminum diaphragm operator, stainless steel body and trim, Teflon packing with Teflon seating for tight shut off. Available up to 2", flanged or screwed.





MINIMUM DISPLACEMENT PACKLESS VALVE

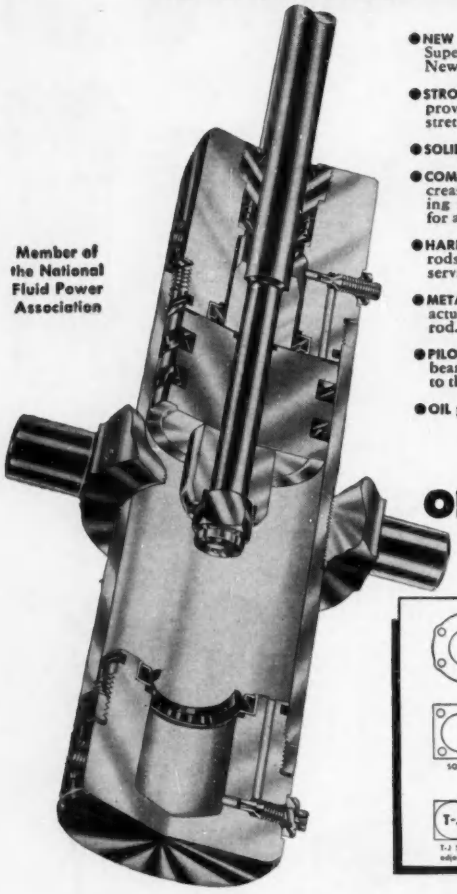
Designed specifically for minimum hold-up in valving capillary tubing. 1¼" dia. body available with special bonnet for solenoid or diaphragm operation, or hand operation.

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all the EXTRAS are standard with

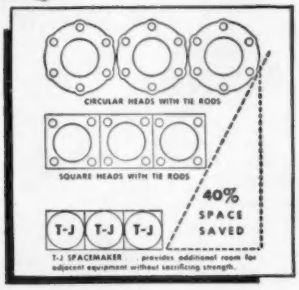
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You *save 40% space* when you switch from outmoded tie rod cylinders to the T-J Spacemaker! It's stronger, too! Fits right into automation programs in countless plants. Delivers top performance and dependability with a big *plus* in advanced features. Wide range of styles, capacities . . . reduces man-hours and costs in all kinds of push-pull-lift jobs. Off-shelf delivery in 64,000 combinations!



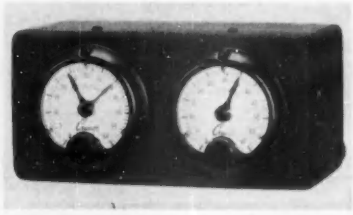
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RIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . CUTTERS . . . CLINCHORS

differential transformer setup introduces no frictional error or drag since there is no contact between its moving surfaces.—John Chatillon & Sons, New York.

Circle No. 18 on reply card

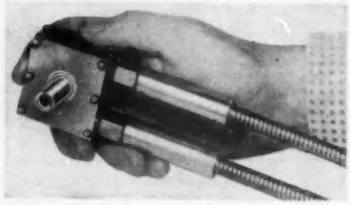
CONTROL DEVICES



DUPLEX TIMER

Designated Type 742, this new duplex cycling timer can control the operation of process work equipment, regulate both idle and operating time on a variety of production machinery, or perform a large number of in-plant functions automatically. After an initial starting circuit is closed, each timer operates in turn, providing a timed interval or delay, restarting the other at the conclusion of each timed period, and then resetting instantly for its next cycle. Each load switch operates within a repeat accuracy of ¼ percent of the full-scale reading and is rated at 15 amp, 125 volts noninductive. Adjustment on each timer is independent of the other, thus providing operational flexibility.—Cramer Controls Corp., Centerbrook, Conn.

Circle No. 19 on reply card



HANDY POSITIONER

The remote controlled positioner above, for independent settings of position and angle, is particularly adaptable to accurate probe position-

Servo Motors For

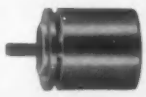
Transistorized Operations

• Meets MIL-E-5272 • −65°C to +125°C temperature range.

Oster

	SIZE 8	SIZE 10	SIZE 11	SIZE 15	SIZE 18
Oster Type	8-5001-00	10-5052-00	11-5101-00	15-5153-00	18-5201-00
Electrical Characteristics:					
Frequency (cps)	400	400	400	400	400
Torque at Stall (oz. in.)	.15	.30	.63	1.45	2.35
No Load Speed (rpm)	6500	6500	6500	5200	5200
Speed at Half Torque (rpm)	4000	4000	4000	3200	3200
Time Constant (sec.)	0.03	0.015	0.016	0.017	0.013
Reversing Time (sec.)*	0.051	0.025	0.028	0.030	0.022
Theo. Acceleration at Stall (rad. sec²)	22500	45000	41500	31000	40000
Operating Temp. Range (°C.)	−54 to +125	−54 to +125	−54 to +125	−54 to +125	−54 to +125
Slot Effect	1.6v/26v	1.0v/36v	1.0v/40v	1.0v/40v	1.0v/40v
Duty Cycle	Cont.	Cont.	Cont.	Cont.	Cont.
Fixed Phase					
Voltage	26	115	115	115	115
R (Stall) Ohms	196	1270	1250	490	280
X (Stall) Ohms	183	1560	1780	890	570
Z (Stall) Ohms	268	2210	2175	1030	640
P.F. (Stall)	0.73	0.57	0.58	0.49	0.45
Effective R (Stall) Ohms	366	3840	3800	2160	1460
Parallel Tuning cond. for unity P.F. (Stall) Mfd.	1.0	0.13	0.15	0.33	0.55
Control Phase					
Voltage	40/20	40/20	40/20	40/20	40/20
*R (Stall) Ohms	480	124	145	58	39
*X (Stall) Ohms	445	215	204	103	77
*Z (Stall) Ohms	660	248	250	118	86
*P.F. (Stall)	0.73	0.50	0.58	0.49	0.45
*Effective R (Stall) Ohms	910	495	430	240	190
*Parallel Tuning cond. for unity P.F. (Stall) Mfd.	0.4	1.4	1.3	2.9	4.1
Mechanical Characteristics:					
Rotor Inertia (gm. cm²)	.47	.47	1.07	3.3	4.0
Weight (oz.)	1.2	2	4.5	8	14
Mounting Type	Synchro	Synchro	Synchro	Synchro	Synchro
Motor Length	.863	.672	1.703	1.625	2.03
Type Shaft	Pinion	Pinion	Plain	Plain	Plain
Shaft Extension	.375	.218	.437	.540	.540
Outside Diameter	.750	.937	1.062	1.437	1.750
Type Connection	Leads	Terminals	Terminals	Terminals	Terminals

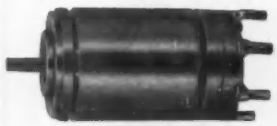
*For 40v connection



Size 8



Size 10



Size 11



Size 15



Size 18

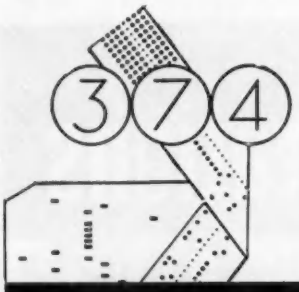
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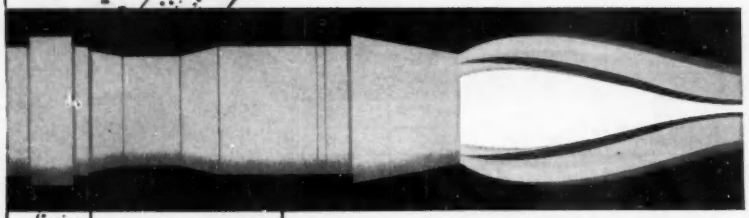
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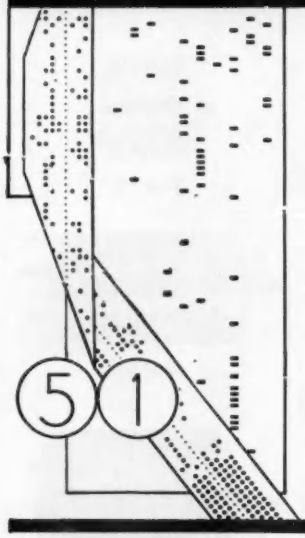


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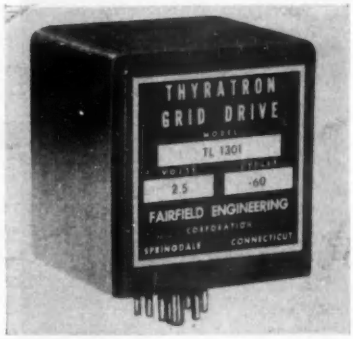
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NEW PRODUCTS

ing although it can develop a thrust of 100 lb. The combination of rotary and linear motion makes it especially suitable for positioning direction-sensing probes in a fluid stream. The probe, up to ¼ in. maximum diameter, is mounted to project through the hollow lead screw. Linear position can be adjusted and measured to 0.001 in. Maximum linear traverse speed is 6 in. per minute and the length of traverse can be varied to suit the application by limit stops. Rotation can be measured to 0.1 deg. Unlimited rotation in ether direction has a maximum speed of 1.5 rpm. The actuator has no electrical components and has sealed grease lubrication, making it especially useful in locations with high vibration stresses and adverse temperatures.–Aerotech Specialties, Inc., Glastonbury, Conn.

Circle No. 20 on reply card



ALL-MAGNETIC

Designed to meet a wide range of thyratron control problems, this new all-magnetic, half-wave thyratron grid drive provides positive and reliable firing of all types of thyratron tubes. The basic unit consists of a fast-response magnetic amplifier which generates a continuously phase-variable pulse. The unit features a rise time of less than 500 microsec and a pulse amplitude which varies with the firing angle to a maximum of 140 volts. Three different input windings are available for maximum-control circuit flexibility. Variable resistance control, ac or dc input signals, or preamplifiers can be used. A high-impedence input requires 200 micro-amp to reset and will match the plate of a 12AX7 tube with a 1.5 volts on the grid for full control. The medium impedance input requires 2 ma and will match the cathode of a 12AT7

NEW! A GUIDE TO AUTOMATIC CONTROL



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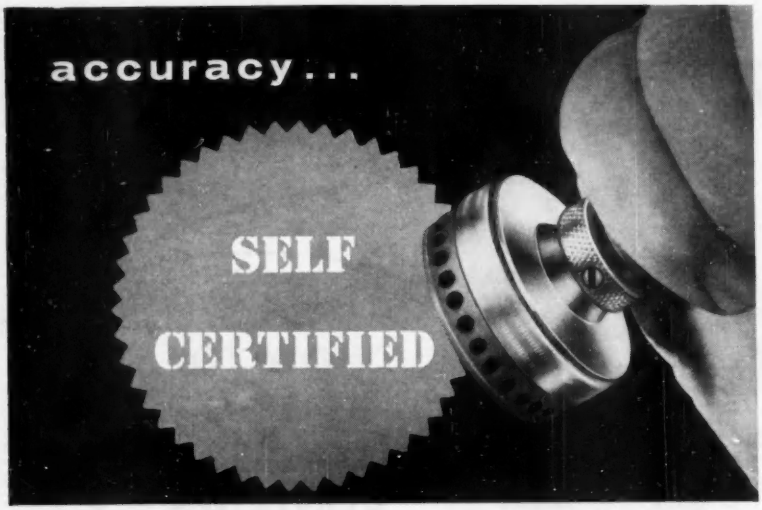
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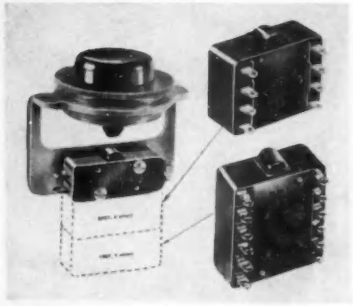
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with 18 volts on the grid for full control. The low impedance winding is especially chosen to match a transistor.–Fairfield Engineering Corp., Springdale, Conn.

Circle No. 21 on reply card



PUSHBUTTON

The manual A4-67 actuator can accept any one of the company's three basic switches without altering the bracket, thus permitting a number of circuit arrangements from spst to tpdt-6 circuit. A knurled ring nut speeds hand installation on panels from $\frac{1}{16}$ to $\frac{1}{8}$ in. thick. The large actuator buttons are available in standard colors of black, red, and green.–Electro Snap Switch & Mfg. Co., Chicago, Ill.

Circle No. 22 on reply card

POWER SUPPLIES



AIR INSULATED

The new series 9000 Hi-Sel dc power supply feature air insulation for minimum weight and selenium rectifiers for small size. Well-suited for industrial or laboratory application, units of the 9000 Series operate from

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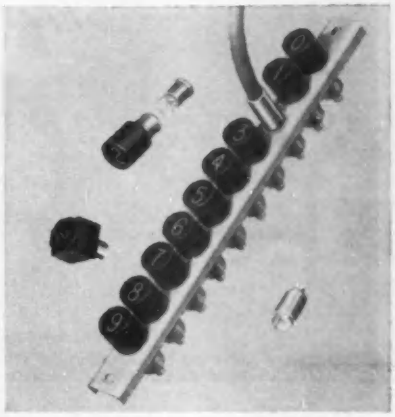
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HETHERINGTON

SWITCHES • INDICATOR LIGHTS • SPECIAL ASSEMBLIES

ENGINEERING NEWS #7

ILLUMINATING ANSWERS FOR COMPUTER PROBLEMS



A newcomer to the Hetherington indicator light line is this low-cost series for analog and digital read-out devices, computers, and a host of precision instruments. Dubbed the *"Digicator"* series, these subminiature lights provide an attractive, easily-mounted display of numerals, letters or symbols in minimum space.

Figures engraved on black plastic lenses are boldly illuminated by midget flange-base AN3140-type incandescent or neon lamps. Serrated spring metal fingers snap lenses and lamps into positive contact—yet allow lenses to be freely rotated to position the figures. A slight pull removes both lens and lamp in one operation for quick, front-of-panel lamp replacement.

Digicator light sockets are available individually, in strips, or as special assemblies to meet individual requirements. To allow lights to be grouped closely together, the usual mounting nut and lock-washer have been replaced with an integral collar which is flared to the mounting surface—like an eyelet—using an inexpensive flaring tool and anvil.

Special patch cord plugs are available to convert any group of Hetherington *Digicator* sockets into a complete, low-cost program board. Simply by substituting patch cords for desired lens and lamp assemblies in a read-out panel, for instance, electrical signals can by-pass the visual stage and feed other equipment directly.

Full details on the entire *Digicator* line are shown in Hetherington's new four-page Data Bulletin L-4—available upon request.

Push-On, Push-Off Switching

FOR SAFETY AND CONVENIENCE



Hetherington "Push-Push" Switches have long been familiar to airline passengers as reading light switches. Now, they're also finding important new industrial uses where their maintained contact pushbutton action offers added convenience and sales appeal, as well as eliminating the hazards of protruding toggles.

Both types have sturdy escapement-type mechanisms that provide positive snap action with moderate operating pressures. The large J100 Series carries a husky 15 amps (inductive) at 28v dc. The considerably newer, and smaller J4000 Series measures only $1\frac{15}{32}$" overall, yet carries a full 3 amps (inductive) at 28 volts.

Dimensions and full specifications on Hetherington "Push-Push" switches will gladly be sent on request.

MOISTUREPROOF SWITCHES

Discipline 10 "Airborne Amps"



Ordinary "earth-loving amps" are fairly well behaved and reasonably predictable. Put them on a plane, however, and it's a different story. Combinations of altitude, humidity, and cramped quarters make them a bit tipsy and rambunctious—often setting off heated battles with nearby components.

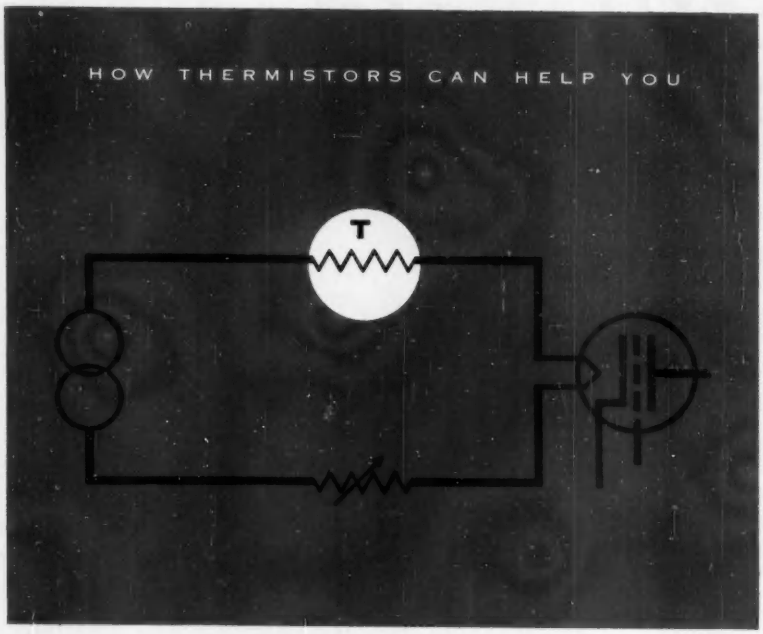
For years now, Hetherington W100 Series pushbutton switches have successfully chaperoned these charges on thousands of military and commercial flights. Specially trained by MIL-S-6743 in the care and handling of amps, these tiny snap-action switches resist salt spray, corrosion, shock, vibration and most other temptations. Each can keep 10 amps (@ 28v dc, resistive) in tow for more than 25,000 operations before its equanimity becomes disturbed.

The entire Hetherington W100 Series includes six different contact arrangements and three button styles. There's also a choice of eight plain- or color-anodized aluminum mounting adapters—including MS25089 types A thru E. Dimensions and full specifications are shown in Bulletin S-2.



HETHERINGTON INC. DELMAR DRIVE, FOLCROFT, PA. • 139 Illinois St., El Segundo, Calif.

NOW IN LARGER FACILITIES TO SERVE YOU BETTER



Providing Surge Suppression in Vacuum Tubes with GLENNITE® Thermistors

The initial high resistance of a Glennite wafer thermistor greatly extends vacuum tube life by preventing quick surge filament burnout.
As shown above, a self-regulating Glennite thermistor inserted in the filament circuit of a vacuum tube offers several thousand ohms resistance as current starts its initial flow. This gives the vacuum tube time to warm up. After several minutes, as the current increases, the resistance of the thermistor decreases to a negligible value allowing normal circuit operation. Thermistors have been used successfully in this and other control applications which range anywhere from gas analysis to volume limiting.



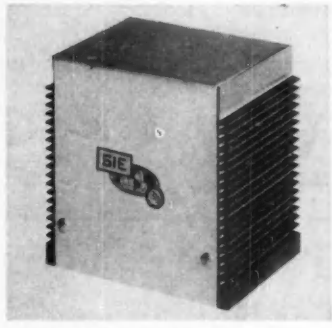
SAMPLE APPLICATIONS OF GLENNITE THERMISTORS ARE GIVEN IN "HOW TO USE THERMISTORS." WRITE FOR YOUR COPY.

Thermistor Division
Gulton Industries, Inc.
METUCHEN, NEW JERSEY

NEW PRODUCTS

a 115-volt, 50-400-cps source and are available with maximum output ranging from 5-15 kv, 2.5 and 5 ma. Sizes vary from 4¼ by 3 by 7¾ in. to 8½ by 6 by 9 in., and weights range from 6 to 13 lb. Units feature low ripple in all current ratings and good dynamic load regulation. By means of a continuously variable auto-transformer in the ac input circuit, the dc output voltage can be varied from 0 to full rated voltage.—Beta Electric Div. of Sorensen & Co., New York.

Circle No. 23 on reply card



TRANSISTORIZED

Pictured is one of a new line of transistorized power converters for use whenever a high voltage dc must be obtained from a low voltage dc. This particular model is designed for a 12-volt input and an output of either 150 volts, 400 ma, or 300 volts, 200 ma. It draws 6.85 amp full load and 1.12 amp no load.—Southwestern Industrial Electronics, Houston, Tex.

Circle No. 24 on reply card

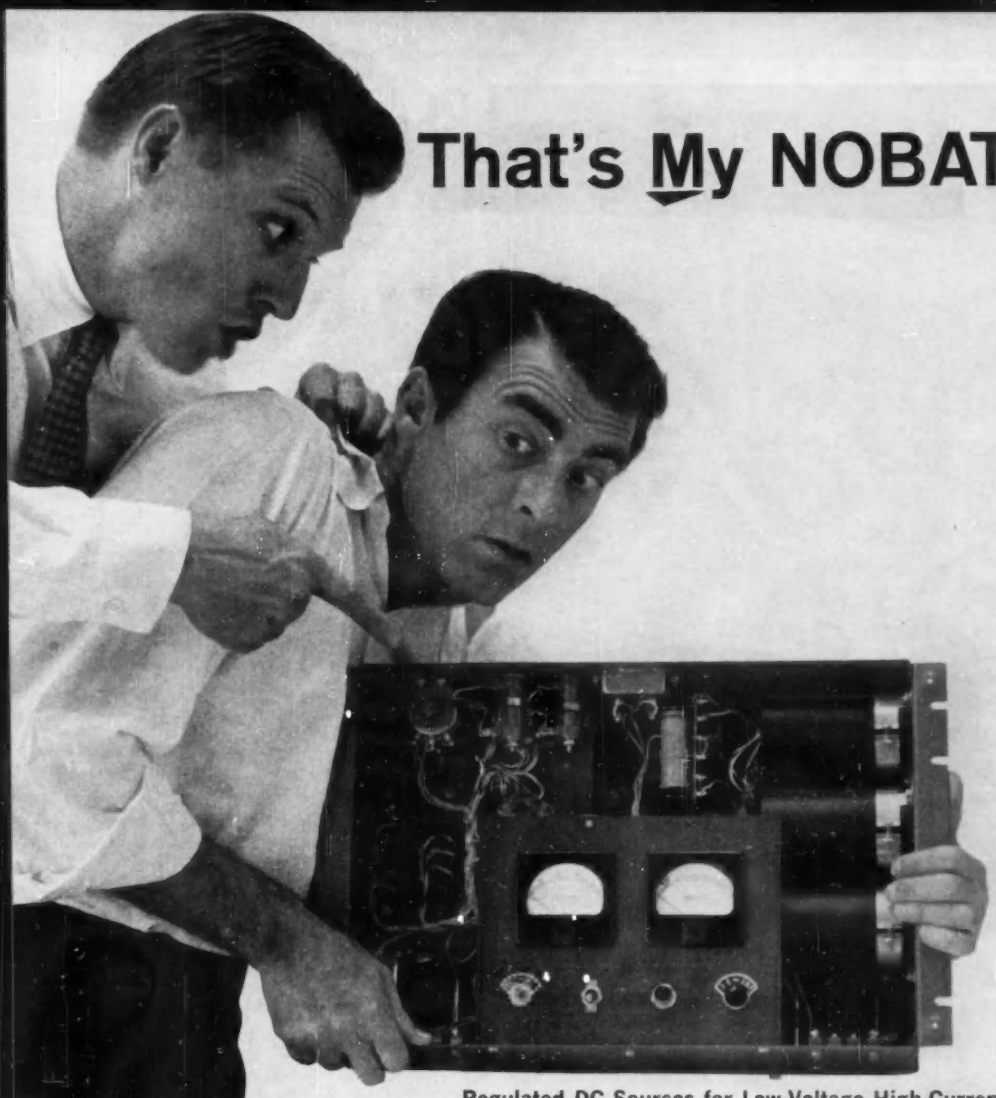
FINAL CONTROL ELEMENTS



MANUAL OVERIDE

Twist-type manual actuators, a new optional feature on this company's line

That's My NOBATRON®!



Regulated DC Sources for Low-Voltage High-Current—
6, 12, 28, 48, 125, 200 Volts at 5 to 75 Amps.

For a reliable *sustained* low-voltage DC supply, delivering the power that covers most laboratory and many industrial applications, and with voltage variation held within ±0.2% ... these Nobatrons just can't be matched —by anything, anywhere.

Nobatrons are in use, by the thousands, all over the world. Many of them have been in operation continuously over a span of years. Conservative design and generous specifications insure long life—especially for wound components.

So effective is the Sorensen regulating principle in correcting line and load drops that output has the stability of a battery supply over extended periods. And the disadvantages of batteries—recharging, acid handling, fixed voltage, temperature problems—are eliminated.

Over-voltage protection is assured by a special safety diode that impels a voltage drop in case of filament failure, with other protective devices safe-guarding all components against power surge.

Most units are designed for rack-mounting, and with cabinets for bench use.

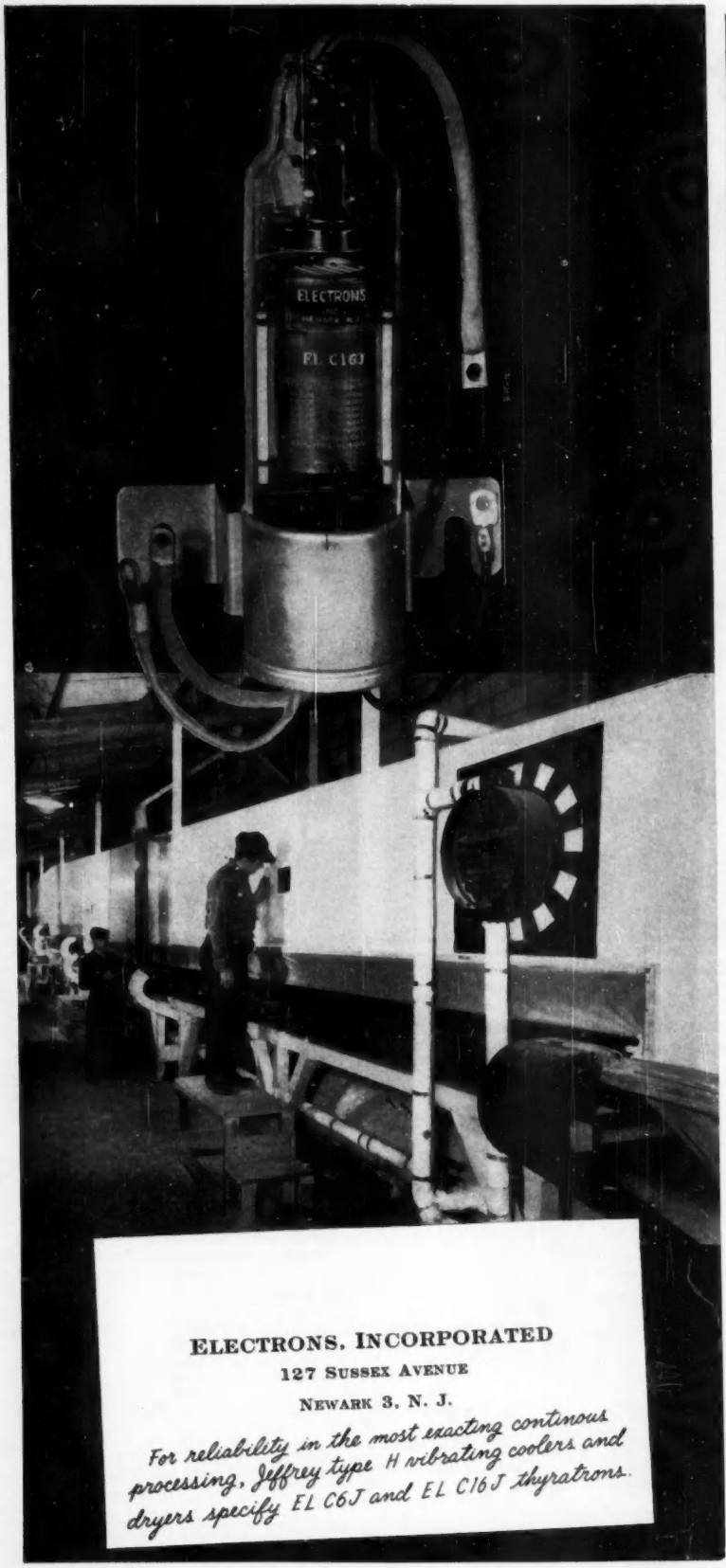
Let your local Sorensen representative give you complete data on these Sorensen DC Nobatrons or write directly for specific information. Please address **SORENSEN & COMPANY, Inc.,** *Richards Avenue, South Norwalk, Connecticut.*

TYPICAL SPECIFICATIONS Model E-28-5* (illustrated)

Output Voltage	28 VDC, Adjustable ±10% with rated accuracy	**Load Range**	0.5 to 5 Amps at Rated Accuracy; accuracy decreases to around ±0.5% for no load.
Input Voltage	95-130 VAC, single phase, 50/60 cycles.	**Ripple Voltage**	1% RMS at 60 cycles. Filters available to reduce ripple to 0.1%
Regulation Accuracy	±0.2% against line from 105 to 125 VAC Input; ±0.2% against load.	**Time Constant**	0.2 second
		Size	Rack height 12¼" Cabinet Size 21¾" x 14" x 15"

*Write for data on other models and capacities.

Sorensen® CONTROLLED POWER FOR RESEARCH AND INDUSTRY



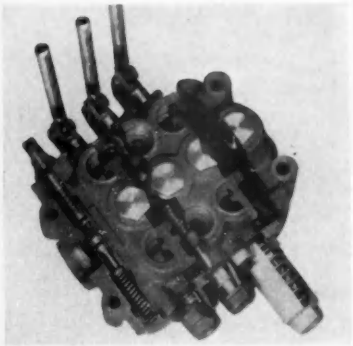
ELECTRONS, INCORPORATED
127 SUSSEX AVENUE
NEWARK 3, N. J.

For reliability in the most exacting continous processing, Jeffrey type H vibrating coolers and dryers specify EL C6J and EL C16J thyratrons.

NEW PRODUCTS

of solenoid-operated air valves, permit control of the air cylinder without electric power. The maker feels that such a feature will facilitate the setup and trial of a system before the wiring is completed. Valves carrying the new feature are either single- or double-solenoid models, full-pressure piloted, and range in size from $\frac{1}{8}$ to $\frac{1}{2}$ in. Air or other noncorrosive gases can be handled.—The Beckett-Harcum Co., Wilmington, Ohio.

Circle No. 25 on reply card



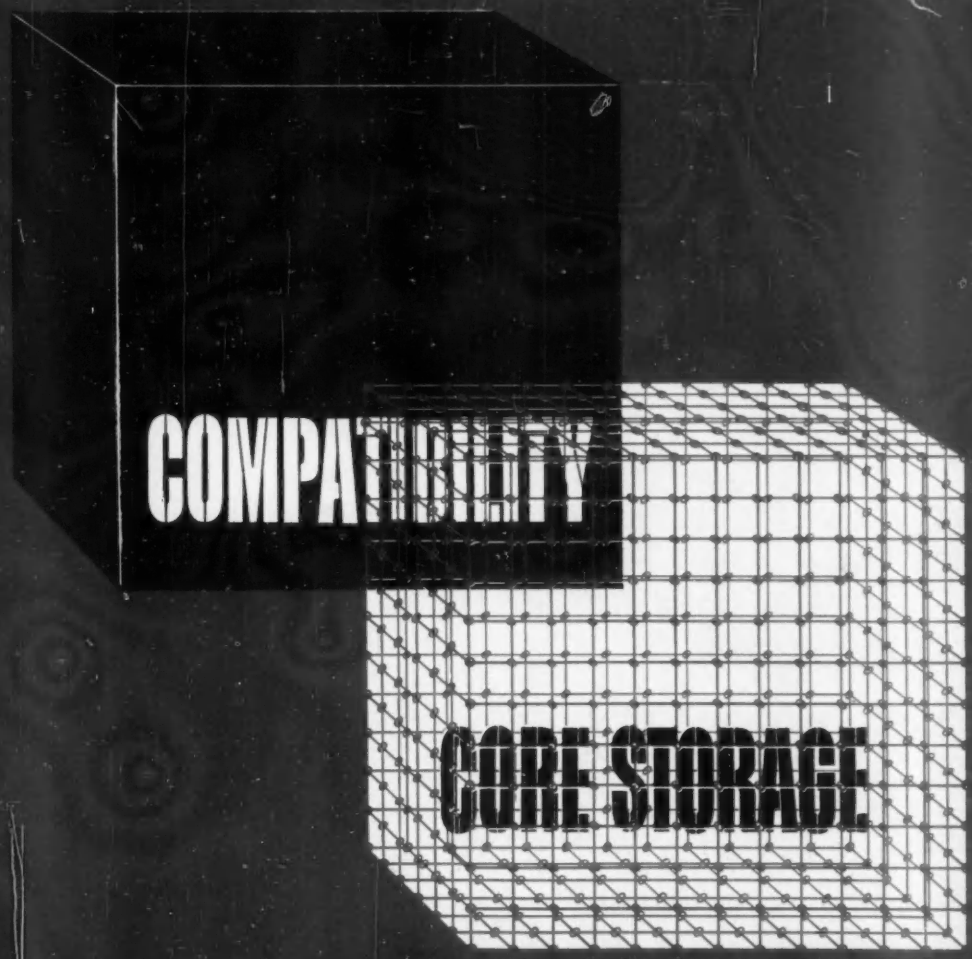
SAVES POWER

Several unusual operating features are incorporated in this new 3200 Series Valve. The 35-gpm unit is available with one to six plungers in completely balanced design, with plungers sealed at each end. Four positions of control—raise, lower, float and neutral—are provided with or without detent (the detent locks the plunger in any desired position). Individual checks are built into each circuit. Another unusual feature is the positive pilot-operated relief valve. This sets the valve to within a maximum of 50 lb variation, compared to normal variation of 200 lb, and permits the use of smaller horsepower engines.—Hydraulic Specialties Co., Waukesha, Wis.

Circle No. 26 on reply card

PROVIDES LOAD "FEEL"

A new rotary actuator selects an automatic flight load "feel" during automatic or manual piloting. During flight controlled by automatic pilot, the actuator operates electrically, responding to signals from the automatic pilot to justify all flight loads through the controls feel spring. During manual control, the crank arm may be



Compatibility and core storage... we're proven specialists in both and enjoy a solid record of accomplishment. Our unique experience gained in pioneering magnetic core memories has resulted in advanced facilities for the manufacture of ferrite cores and systems based on magnetic core technology. Completely transistorized magnetic core memories, core buffer units and tape-to-tape conversion systems are currently in production... equipment that provides greater compatibility and balance in data handling systems. If your specific application calls for magnetic cores, core matrices, buffers, memories, tape translators or special purpose digital data processing systems, call in our technical representatives.

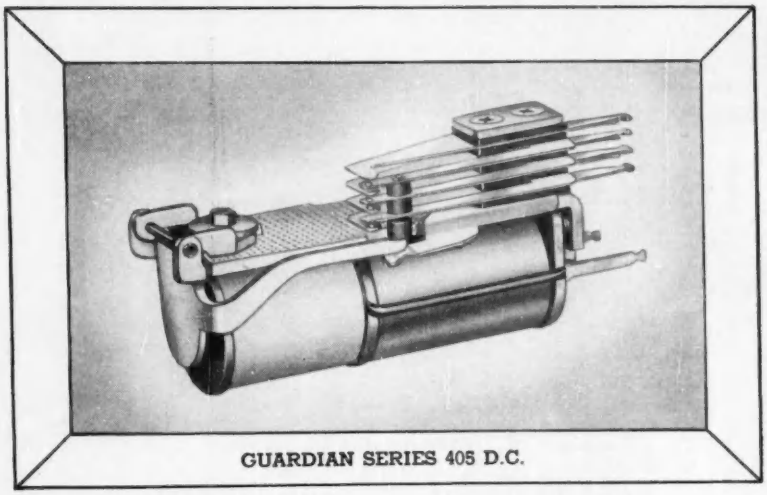
TELEMETER MAGNETICS *Inc.*

2245 Pontius Avenue, Los Angeles 64, California

Write for detailed information on Model No. 1092-BU-2R Magnetic Storage Buffer.

EVERYTHING UNDER CONTROL

WITH GUARDIAN®
TELEPHONE RELAYS



GUARDIAN SERIES 405 D.C.

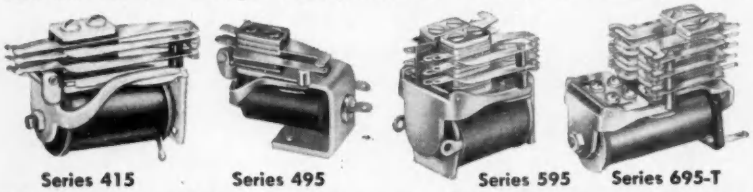
High Reliability • Superior Quality
Minimum Adjustment • Long Life

This Guardian Series 405 D.C., Telephone Relay, tested to critical gauging and adjusting practices, performs with utmost reliability at high speeds under rigorous operating conditions. It challenges comparison, is completely *interchangeable* with all standard telephone relays. Arrange for delivery of production samples. Make your own tests. Coils are single, double, or triple wound. Precision time-delays available on release or attract. Switching arrangements, contact sizes and materials to your specifications.

MORE POWER in LESS SPACE

Pin Hinged Armature Reduces Friction	Sensitive With Low Operating Power	Designed for Base Mounting	Terminals Accessible for Easy Wiring

Additional Guardian Telephone Relays Available in Many A.C. and D.C. Versions



Series 415 Series 495 Series 595 Series 695-T

Write—Submit Your Requirements for Specific Recommendations

GUARDIAN ELECTRIC
MANUFACTURING COMPANY
1623-M W. WALNUT STREET, CHICAGO 12, ILLINOIS

NEW PRODUCTS

electrically declutched. When this is done, a magnetic damper eliminates oscillation as the artificial feel spring seeks its neutral position.—Lyndon Aircraft, Inc., Newark, N. J.

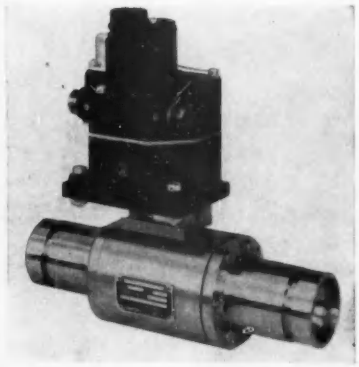
Circle No. 27 on reply card



PLASTIC VALVE

A recently developed all-plastic solenoid valve series is designed to handle caustics, acids, and highly corrosive media. No metal in the valves, known as the SV-5100 Series, comes into contact with the media being handled. Compact and light-weight, they have a bubble-tight seal that adds to their life. No fittings are required and operation is feasible in any position. Power required is at 115 volts, 60 cycles.—Valcor Engineering Corp., Kenilworth, N. J.

Circle No. 28 on reply card

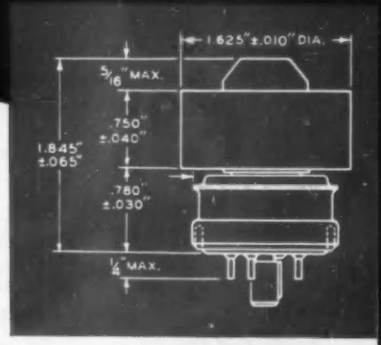


DC MOTOR DRIVEN

A new line of stainless-steel shutoff valves available in sizes from ¼ in. to

New RCA Beam Power Tubes With New High-Efficiency Radiator





Higher Power Output...370 Watts up to 150 Mc
Higher Plate Dissipation...250 Watts up to 500 Mc

Unilaterally interchangeable with the 4X150A and 4X150D, these superior new RCA tubes feature a new speçially designed, high-efficiency radiator which is hard soldered directly to the plate for better heat transfer. The 7034 and 7035 offer substantially higher power output capability at frequencies up to 150 Mc, and reliable operation with higher plate dissipation at frequencies up to 500 Mc.

Small and compact, the RCA-7034/4X150A and the RCA-7035/4X150D are useful as af power amplifiers and modulators, wide-band amplifiers in video applications, linear rf power amplifiers in single-sideband suppressed-carrier equipment, and class C amplifiers or oscillators.

Your RCA Field Representative at the RCA Office nearest you will be glad to give you sales information on these new types. For technical bulletin on RCA-7034/4X150A and RCA-7035/4X150D, write RCA Commercial Engineering, Section K-56-Q, Harrison, N. J.

TYPICAL CCS OPERATION
RF Power Amp. & Osc.—Class C Telegraphy

Up to 150 Mc.		
DC Plate Volts	1500	2000
DC Plate Ma.	250	250
Driving Power (watts)	1.5	2.5
Power Output (watts)	260	370
At 500 Mc.		
DC Plate Volts	600	1250
DC Plate Ma.	170	200
Driver Power Output (watts)	15	30
Useful Power Output (watts)	50	140

RCA Field Offices

East: HUmboldt 5-3900
744 Broad Street, Newark 2, N. J.

Midwest: WHitehall 4-2900—Suite 1181
Merchandise Mart Plaza, Chicago 54, Illinois

West: RAymond 3-8361—6355 E.Washington Blvd.
Los Angeles 22, California

RADIO CORPORATION OF AMERICA
Electron Tube Division • Harrison, N. J.

BIG-POT PERFORMANCE in Miniature-pot size

Waters PRECISION MINIATURE POTENTIOMETERS

are built, tested, and certified* to such rigid specifications as AIA, RETMA, JAN-R-19, MIL-E-5272A, and other applicable military specifications. *This new line* of single-turn pots packs Waters traditional performance into tight spots.

*Complete test data on request.

NOW! A complete single-turn-pot line from Waters

CHECK THESE SPECIFICATIONS

Model	Resistance Range (ohms)	Standard Linearity†	Case Dia. (inches)	Standard Shaft Dia. (inches)
WP ½	½ to 250K	1.0%	½	⅛
WP ⅞	½ to 250K	0.5%	⅞	⅛ or ¼
WP 1 1/16	½ to 350K	0.5%	1 1/16	⅛
WP 1 1/8	½ to 350K	0.5%	1 1/8	¼
WP 1 5/8	½ to 500K	0.5%	1 5/8	¼

† For best possible linearity submit detailed specifications.
Servo mount standard, three hole and bushing mounting available.

A micro-miniature potentiometer that meets the requirements of today and tomorrow for high performance, while retaining the rugged dependability of the approved Waters design.

NEW



TYPE WP 1/2

Proved reliable in thousands of military and commercial installations. Available in dual unit with Waters new concentric shaft construction.



TYPE WP 7/8

NEW

Offers Waters reliability in the AIA nominal one-inch diameter. Available as servo or bushing-mounted unit, it gives high precision in a miniature size.



TYPE WP 1-1/16

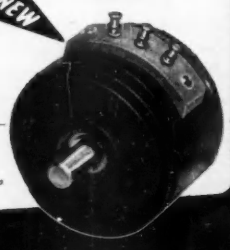
Provides higher resistance values with better resolution and linearity, yet is a miniature unit in every sense. Available as dual unit with concentric shafts.



TYPE WP 1-1/8

NEW

Reliability and precision equal to many 2-inch or larger potentiometers results from Waters proved miniature design and assembly techniques.



TYPE WP 1-5/8

Write for catalog of the Waters complete single-turn-pot line; *precision, trimmer, low torque, miniature.*

Waters MANUFACTURING, inc.

APPLICATION ENGINEERING OFFICES IN PRINCIPAL CITIES

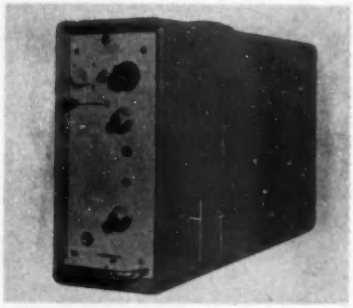
Wayland, Massachusetts

NEW PRODUCTS

1 in., has been designed for cryogenic applications. Featuring the company's straight-through Flo-Ball design, these units will handle corrosive fluids and gases in a temperature range of minus 320 to plus 160 deg F.—Hydromatics, Inc., Cedar Grove, N. J.

Circle No. 29 on reply card

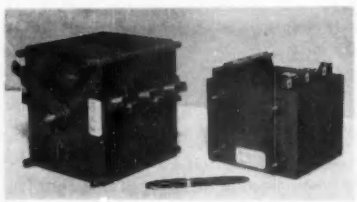
COMPONENT PARTS



LOW DRIFT—HIGH GAIN

The Model 450-1800A amplifier above is one of a new series designed to drive an optical galvanometer, oscilloscope, or tape recorder. Input characteristics include an impedance of 200 K differentially between terminals, or 100 K each input lead to ground. Common mode rejection at dc is 100 db, to 400 cps, 80 db, and from 400 cps to 30 kc, 74 db. Equivalent input drift is plus or minus 2 microvolts; equivalent input noise ranges from 5 microvolts peak to peak at 0 to 10 cps, up to 50 microvolts at 0 to 30 kc.—Sanborn Co., Waltham, Mass.

Circle No. 30 on reply card



TRIMMED DOWN

A new high-temperature selenium rectifier for aircraft applications meets and exceeds MIL-P-7212B. A six-phase, full-wave unit with a rating of 100 amp, 28 volts, it will operate at 125



servo problems stock units can't solve

This equipment "does the job right" because it was especially designed for a single application . . . by a company whose major function is solving individual servo control problems with complete, precisely engineered and manufactured servo assemblies.

Of course, if you just want servo *components*, Daystrom Transicoil can provide them to the highest order of precision and accuracy. But it is in the "package" engineering of unique assemblies that Daystrom Transicoil's experience and creative imagination offer the greatest value. And in most cases, these assemblies cost no more than the individual components would purchased separately.

Check out your next servo problem with Daystrom Transicoil first. Ask for the new gear-motor availability guide if you haven't yet received a copy.

DAYSTROM TRANSICOIL CORP.

A Subsidiary of Daystrom, Inc.

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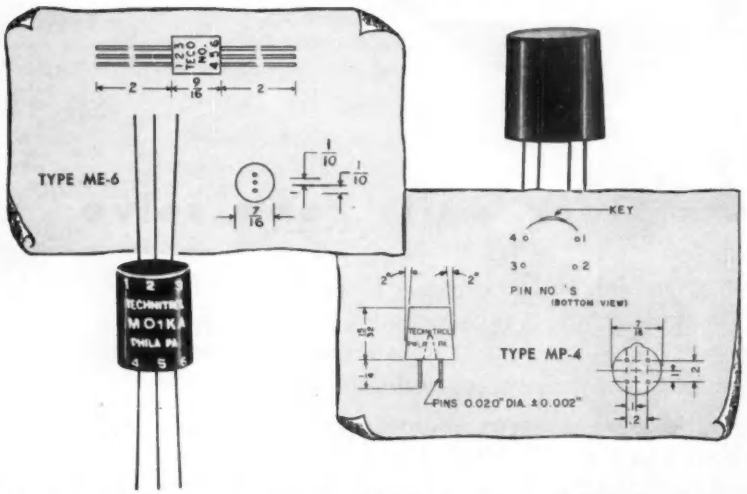


miniature

encapsulated

PULSE TRANSFORMERS

by TECHNITROL



Wound on ferrite cores, the Type M series is available in a variety of windings to cover pulse widths from 2 microseconds down to .05 microsecond, wound inverting or non-inverting.

While the M series is particularly adapted to subminiature and transistor circuits, we design and build pulse transformers to fit specific circuits or to meet definite mechanical or thermal requirements, including MIL-T-27A.

Additionally, Technitrol makes a complete line of lumped and distributed parameter Delay Lines and a variety of electronic test equipment.

For additional information, write today for our bulletin

TECHNITROL
ENGINEERING COMPANY
1952 E. Allegheny Ave., Phila. 34, Pa.

NEW PRODUCTS

deg C. Weight is only 5.5 lb. Photo compares the new with the old model, left, which weighs 8.8 lb and is somewhat larger. Size and weight reduction are attributed to a new double-sided cell design.—Components Div. of IT&T Corp., Clifton, N. J.

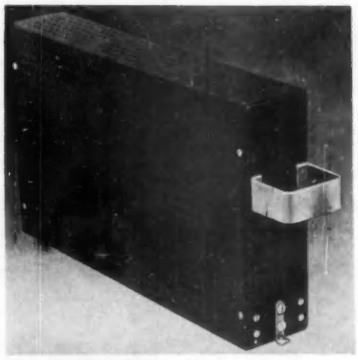
Circle No. 31 on reply card



MINIATURE CHOPPER

Recently made available, this new all-electronic chopper contains no moving parts and for all practical purposes has a minimum operating life of 5,000 hours. Used primarily as a dc to ac voltage converter sensitive to the phase of the reference voltage, it can also serve to convert ac into dc voltage. Major features of the new chopper include zero phase shift, 180-deg dwell time, wide frequency range, and unlimited life when properly applied. Maker says the unit meets or exceeds the requirements of MIL-E-5272A. Reference power is 6.3 volts at 2 ma.—Kearfott Co., Inc., Little Falls, N. J.

Circle No. 32 on reply card



WEIGHS ONLY 5 LB

Model LGSR-1, a new lightweight glide slope/slope receiver, has a fully transistorized internal power supply, and, according to the manufacturer, is the lightest on the market. Contained in a ½ ATR short-length case, which

Pete Marenholtz discusses PREFLIGHT MISSILE CHECKOUT

Prior to launching a missile, a full-scale dress rehearsal is conducted in order to enact every predictable contingency which might occur during flight. Considering the multitude of intricate and remotely controlled actuations which must be checked within a very short time interval, and the speed with which the corresponding decisions must be made, it is easy to recognize the need for the faster-than-human, more-reliable-than-human capabilities of the equipment monitoring this dress rehearsal. The possibility of human errors can not be tolerated, not only out of concern for the safety of personnel, but in order to avoid damaging the expensive missile itself.

The preflight missile checkout system incorporates all operations necessary for the final preparation of the missile for flight. To meet the requirements of unfailing high-speed repeatability, the use of electronics is mandatory. The electronic checkout equipment must:

1. Position missile controls for flight and precess inertial guidance elements for a predetermined flight plan. This involves making decisions which may be changed again during the final seconds prior to the moment of launching. Errors in judgment or of actuation must be eliminated.
2. Actuate all controls on the missile and sense correct functioning.
3. Provide an immediately available record of all tests for evaluation and making of final decisions relating to the missile's readiness for firing.

The mechanics of performing the above checkout functions falls into the realm of logical decisions. More specifically, the decisions are made more reliable and accurate by resorting to electronic decision elements. One technique is to store into a memory device all the necessary commands, off-limit conditions, and sequencing instructions required for the checkout.

The type of memory device required for a particular missile depends upon the speed with which checkout operations must take place. For instance, present-day missile checkout time scale requirements may be satisfied with punched paper tape programs. Faster access time, if required, may be achieved by employing magnetic tape or magnetic cores.

In a typical system the selection of controls to be actuated and electrical points to be instrumented is accomplished by positioning stepping switches in response to signals generated by the program memory device. The signal from the instrumented point is converted to a digital signal and compared in an automatic comparator with predetermined limits likewise stored in the memory device. This comparator operates as a time-digital comparison and comparisons therefore can be made at high speed and with digital accuracy.

A prime requirement for an automatic checkout system is absolute reliability. The time and the money at stake are enormous and reliability of the ground station system should, if possible, exceed that of the missile itself by at least an order of magnitude. In the case of equipment carried on board the missile it is often necessary to compromise between reliability and weight. But ground station equipment is invariably designed for reliability regardless of weight.



Pete Marenholtz, engineer, specializing in transistor digital circuitry, discusses automatic preflight missile checkout.

Redundancy is used (over and above conservative design and quality components) in achieving this extreme degree of reliability. Each internal operation of the system is performed twice and the results are compared before initiation of a main missile system function. A malfunction anywhere in the checkout which could not otherwise be avoided, is therefore immediately detected and measures are taken to protect the overall missile system. In the binary portions of the system parity checks are employed for added reliability insurance.

In developing such systems as the preflight missile checkout system, the progressive nature of military research has advanced automation techniques to their present high level and has paved the way for their counterpart in industrial applications.

By applying the latest proven techniques, our well-qualified staff at Daystrom Systems is prepared to take single responsibility of assembling and installing a system to meet your needs. We are currently compiling a file of new applications and papers on various parts of systems, both industrial and military. If you are interested in receiving the file and periodic additions, please write us.

DAYSTROM SYSTEMS
Division of Daystrom, Inc., 5640 La Jolla Boulevard
La Jolla, California Telephone GLencourt 4-0421

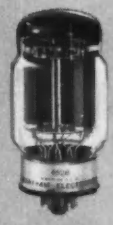


TELEPHONE TYPES — A highly specialized line of vacuum and gas filled types in both the 300 and 400 series.



THYRATRONS—An extensive line of thyratrons for use as grid control rectifiers, relays and noise generators. Inverse voltage ranges from 100 to 5,000 volts. Sizes from subminiatures to ST 16 bulbs. Filamentary as well as hot and cold cathode types are available.



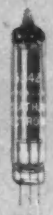


TWIN POWER TRIODES—The most complete line of high current twin power triodes developed especially for regulated power supply usage. Current and power ranges up to 800 milliamperes and 60 watts respectively. Included are rugged types in both low and medium mu construction.



RECTIFIERS—Both vacuum and gas filled tubes with peak inverse voltage ratings from 200 to 15,000 volts. Included are tubes with special features such as fast warm-up, cold cathodes, clipper service ratings and rugged construction.

HYDROGEN THYRATRONS—Used primarily as switching tubes in line type radar modulators, these tubes permit accurate control of high energy pulses. Sizes from miniatures to the VC 1257. Peak pulse power ranges from 10 kilowatts to 33 megawatts.



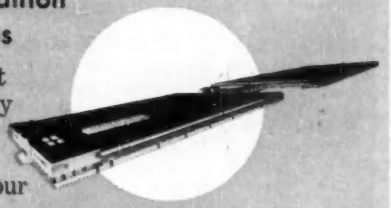
VOLTAGE REGULATOR AND REFERENCE TUBES—Gas filled tubes designed to specific voltages for regulating small currents. Also used to make available stable reference voltages for high current supplies. Sizes from subminiatures to bantams, including many reliable, ruggedized types.

CHATHAM

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The creative engineering that has been responsible for many Chatham "originals", now has larger and improved facilities to help you solve your special purpose tube problems.



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***Division of* TUNG-SOL ELECTRIC INC.**
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NEW PRODUCTS

sets on a dual shock mount, the unit provides reception of 90/150 cps tone-modulated glide slope signals for navigating aircraft on the instrument landing system. A solenoid-operated device drives the switch that selects the correct crystal for each frequency. Only the crystals are switched, and no other tuning functions are required. Now in production, the unit will be available for operating on 12 or 24 vdc or 115 volt, 400 cps current.–LearCal Div. of Lear, Inc., Santa Monica, Calif.

Circle No. 33 on reply card



CHOPPER VARIETY

The Syncroverter Switch, a precision, nonresonant inverter, is now being offered in over 75 optimized variations for low-power and dry-circuit applications. Special low-noise and high temperature units are available, as are variations in contact ratings, vibration and shock resistance, and frequency ranges. Mounting arrangements include standard seven-pin plug-in bases and solder-lug connectors. Miniature and larger units can be furnished in either spdt or dpdt action.–The Bristol Co., Waterbury, Conn.

Circle No. 34 on reply card



LOW POWER

This single-phase, two-capacitor, high-torque synchronous motor runs at 12,000 rpm and has 0.85 oz.-in. pull-out torque with a power consumption of only 20 watts. It can be hooked up as a two-phase motor at 0.93 oz-in. pull-out torque and 17 watts total consumption, or as a single-capacitor type

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Linear Accelerometer
Type LA-500
Shown actual size.

LINEAR ACCELEROMETERS for Aircraft and Missiles

HONEYWELL LINEAR ACCELEROMETERS of the Type LA-500 Series are true linear, non-pendulous type instruments, inherently insensitive to cross-coupling accelerations. These instruments are available in a variation of ranges from ±1 G to ±60 G and can be provided with two potentiometer pickoffs. Essentially constant damping is maintained automatically throughout the entire operating range of −65°F. to +175°F. No warm-up time is required.

The combination of constant damping, high performance, small size and ruggedness makes HONEYWELL LINEAR ACCELEROMETERS of the Type 500 Series ideally suited for aircraft and missile applications where the most severe environmental conditions are encountered. Write for Bulletin LA-500, Minneapolis-Honeywell, Boston Division, Dept. 34, 1400 Soldiers Field Road, Boston 35, Mass.

DESCRIPTIVE DATA

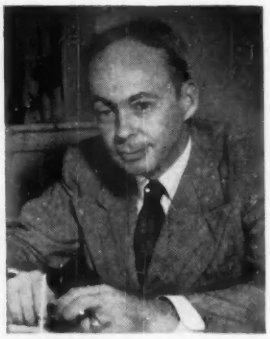
- **RANGE:** Up to ±60 G full scale.
- **DAMPING RATIO:** 0.6 ±0.2 (from −65°F. to +175°F.).
- **LINEARITY:** 1% of full scale.
- **PICKOFF:** Can be provided with 2 potentiometer pickoffs (center taps optional).
- **SIZE:** 1 7/16" dia., 3 1/4" long.
- **WEIGHT:** 1 lb.

MINNEAPOLIS **Honeywell** H HONEYWELL

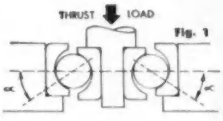
BOSTON DIVISION

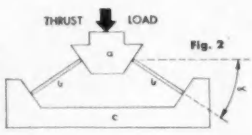
MICRO-BEARING ABSTRACTS

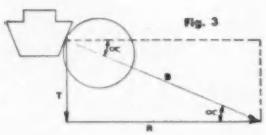
by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings, Inc.



CONTACT ANGLE







Contact angle is the angle between a plane perpendicular to the bearing axis and a line connecting the two points on a given ball where the ball makes contact with the raceways when the bearing is subjected to a pure thrust load. In *Fig. 1*, the contact angle is represented by angle α. The significance of the contact angle is revealed by an examination of the forces present in a thrust loaded bearing.

In *Fig. 2*, a simplified version of *Fig. 1*, the shaft and inner ring combination are represented by the plug *a*, the "working diameters" of the balls and represented by the rodlike members at *b*, and the outer ring is represented by the tapered cup *c*.

The contact angle is α. This diagram represents a three-dimensional structure with as many equally spaced rods, *b*, as there are balls in the bearing.

The primary concern in design is the amount of compressive force to which rod *b* is subject, which is the force with which a given ball is pressed against the raceways. This force can be calculated by constructing a parallelogram of forces as shown in *Fig. 3*.

The sides T and R, are vector quantities, and diagonal B is the vector sum of T and R. Furthermore, the vector sum of the thrust components on all the balls equals the total thrust load on the bearing. The vector sum of the radial components on all the balls is zero. Vector B, the force actually felt by the raceways and balls, compared to vector T, the thrust component, varies significantly with changes in the size of the contact angle and is directly proportional to the thrust load component and inversely proportional to the sine of the contact angle.

Example I:

A bearing is carrying a pure thrust load of 21 pounds. Assuming seven balls in the bearing, each ball will have an axial load component of three pounds, since a thrust load is shared equally by all the balls. While the axial component on each ball is only three pounds, the actual compressive force, or squeeze, felt by the ball and raceways is considerably greater than this value.

With a contact angle of five degrees:

$$B = \frac{T}{\sin \alpha} = \frac{3 \text{ lbs.}}{\sin 5^\circ} = 34.5 \text{ lbs.}$$

Thus we see that with a five-degree contact angle the actual load felt by each individual ball is actually considerably greater than the total 21 pound thrust load on the bearing.

Example II:

Using the thrust conditions in Example 1, the contact angle is increased to 20 degrees, by selecting a bearing with a larger value of radial play.

$$B = \frac{3 \text{ pounds}}{\sin 20^\circ} = 8.78 \text{ pounds}$$

A 15 degree increase in contact angle produced a 74.5% reduction in ball-to-raceway contact stress. This relationship should be noted by anyone who writes bearing specifications. The operational qualities of the bearing, such as low running and starting torque and bearing life, are a function of the ball-to-raceway contact stress. Thus the contact angle is highly significant.

It is not necessary for a bearing user to calculate or specify the contact angle desired. It is only necessary to remember that low values of contact angle are associated with low radial play, and high values of contact angle are associated with high radial play. In addition to the above considerations, gyratory forces become extremely important factors in determining optimum contact angle in high speed applications.

A more complete discussion of contact angle is found in our design handbook.

DESIGNERS HANDBOOK OFFERED *FREE* TO ENGINEERS

If you work with miniature bearings, you'll find this new, 70-page authoritative publication a great help in solving problems in designing instruments or small electro-mechanical assemblies.



It will be sent free to engineers, draftsmen and purchasing agents. **Write to: New Hampshire Ball Bearings, Inc., Peterborough 1, N.H.**

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

NEW PRODUCTS

at 0.45 oz-in. pull-out torque, 30 watts. The size-18 unit meets MIL-E-5272, weighs 14 oz, and is furnished with pinion-type shaft and a black oxide finished stainless steel case.—John Oster Mfg. Co., Racine, Wisc.

Circle No. 35 on reply card

ELIMINATES SATURATION

Two new servo system components, the Models QR-400 and QR-60 Quadrature Rejectors, are designed to eliminate the troublesome problem of quadrature in ac servos. Iron saturation in high-gain amplifiers is no longer a problem. The interstage unit will pass a signal with 6 db maximum attenuation while rejecting quadrature of 40 db minimum. Temperature range of the units is minus 55 deg C to plus 100 deg C. Available for 400 and 60 cps applications, they measure 1½ in. cubed.—Feedback Controls, Inc., Waltham, Mass.

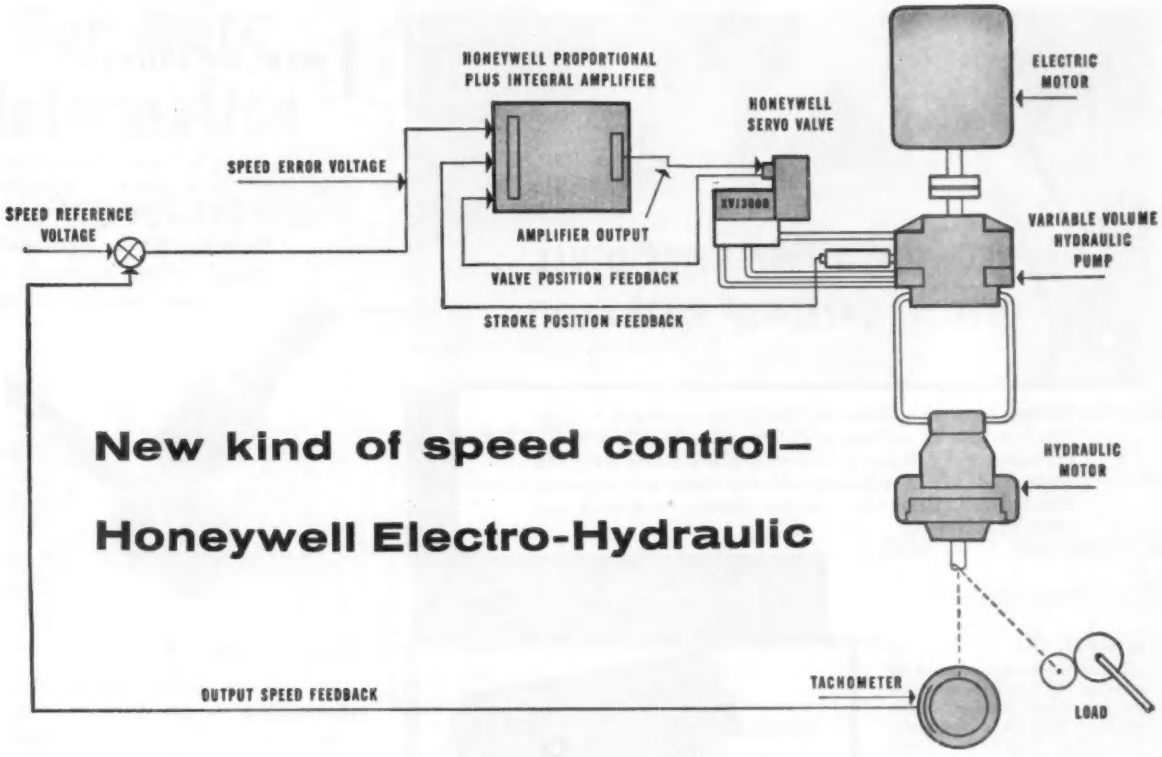
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ACCESSORIES & MATERIALS



"LATERAL ACTION"

Oblong connectors with 15 butt-type contacts represent a new concept called "lateral action" mating, in which interconnecting equipment is fastened by means of a sliding action. This idea makes possible a more compact equipment design and improves reliability through a more secure electrical and mechanical contact. Connectors are rated at approximately 500 volts at 10 amp per contact. Mated pairs measure



New kind of speed control—

Honeywell Electro-Hydraulic

Only an electro-hydraulic speed control system can give you all these advantages.

- Wide speed range—ranges of 1,000 to one are readily possible
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- Negligible droop under load
- Infinitely variable speed control
- Easily adjustable speed

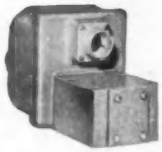
THE SPEED CONTROL diagram above is a typical example that shows the flexibility of Honeywell Electro-Hydraulic Control systems.

Honeywell servo valves and transistor amplifier combinations make new building blocks available for dozens of applications.

Rugged and dependable, they are smaller and more compact, have high speed of response, are easy to adjust and inexpensive to install.

For complete information, including realistic delivery dates, call, wire or write Minneapolis-Honeywell Machine Controls Division, Dept. CE-11-210, Minneapolis 8, Minn.

Flexible building blocks to do the job



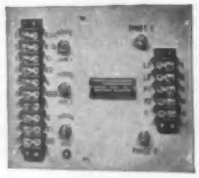
3-Way Valve (XVJ300)
Output Flow (no load)
100 psi—3.5 gpm
1000 psi—9.9 gpm



4-Way Valve (XVJ303)
Output Flow (no load)
100 psi—1.5 gpm
1000 psi—5.0 gpm



3-Way Valve (XVJ302)
Output Flow (no load)
100 psi—2.0 gpm
1000 psi—6.0 gpm



Amplifier (XRJ301)
Transistor Servo Amplifier
High gain, multiple input amplifier with superior reliability.

Honeywell

First in Controls

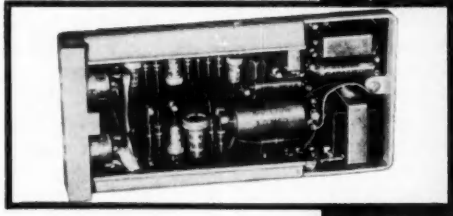


NEW SERVO AMPLIFIERS DEVELOPED AT DAYSTROM INSTRUMENT

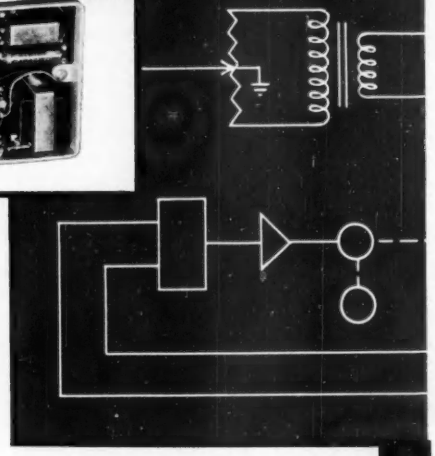
Typical items developed by Daystrom Instrument in conjunction with its systems work are these miniature servo components. Additionally, Daystrom offers custom designed units and servo sub-systems for data processing, automation systems, fire control systems, simulators and other applications.

3 WATT,
all transistorized designed to operate 400 cycle motors with 35 volt center tapped control windings. Overall Dimensions—1.30 inches x 1.30 inches square; Length 5.50 inches... Weight 6.5 ounces, Input Impedance 10K ohms, Gain 350, Power Supply 28 VDC. Amplifier package is plug-in type using a Winchester Type SMRE7P-G plug.





4 WATT,
all transistorized designed to operate 400 cycle servo motors with 26 volt control windings. Width—1.06 inches; Height 2.68 inches; Length—5.43 inches... Weight 7.1 ounces, Input Impedance 20K ohms, Gain 1000, Power Supply 28 VDC.



Our servo engineers are ready to help you. Let us have your requirements.

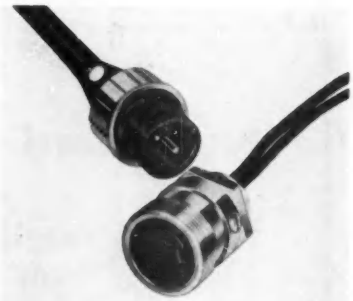
DAYSTROM INSTRUMENT

Division of Daystrom Inc.
Archbald, Pennsylvania

NEW PRODUCTS

1¼ in. sq by 3½ in. long. Contacts are gold over silver plated.—Amphenol Electronics Corp., Chicago, Ill.

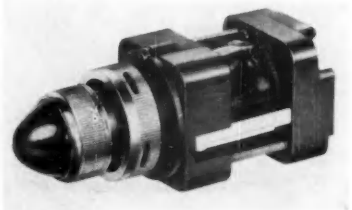
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EASILY MOUNTED

The pair of electrical connectors shown here is one of a new line that mounts directly through knockout or threaded holes in wiring boxes, panels, or ducts. The units are called "changeouts" by the manufacturer because their use on control equipment such as switches, solenoids, level detectors, etc., greatly reduces the time required to replace defective assemblies. Available with 2, 3, or 4 contacts for 8 to 20 amp applications, they have a 600-volt rating.—Joy Mfg. Co., St. Louis, Mo.

Circle No. 38 on reply card



PUSH-TO-TEST

The push-to-test pilot light shown here enables an operator to test the bulb simply by pushing on the color cap. A positive contact "feel" is said to eliminate any doubt as to whether the unit is in the test position. Oil-tightness of the unit is maintained in both the normal and the depressed or test position. All internal connections are pressure connections of silver-plated beryllium copper.—Square D Co., Milwaukee, Wis.

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(100) ABOUT FERRITES. General Ceramics Corp. Bulletin F-557, 8 pp. A sober presentation of the story of these increasingly important components for computers and programmers, permanent magnets, antennas, etc. The ones here are useful as impedance-type elements up to somewhat above 100 mc.

(101) GAGING AND INDICATING. Sensitive Research Instrument Corp. Bulletin, 4 pp. Some interesting data on an automatic inspection device that can also control between electrical maximum and minimum limits. Heart is a moving contact that senses an indicator and is adjusted to predetermined electrical values.

(102) RELAYS. Relay Sales, Inc. Catalog. 34 pp. What's available from a unique relay merchandiser handling all major makes in sizes ranging from microminiature to the size 3 motor starter. It does its own fabrication from stock.

(103) TRAVERSE CLOSURE. Electro-Data Div. of Burroughs Corp. Brochure 5-04-130, 8 pp. One of a series on Datatron computer applications, this brochure outlines computer solution to problems in civil and architectural engineering dealing with right-of-way, subdivisions, etc.

(104) FLOW REGULATORS. Waterman Engineering Co. Brochure, 8 pp. Diagrams, charts, and text explain principles of new flow regulators and describe aircraft and other applications.

(105) AIRBORNE NAVIGATION. Kearfott Co., Inc. Bulletin, 12 pp. Describes Kearfott-built instruments that singly or together satisfy Air Force and/or Navy requirements for heading reference and navigation systems that will operate in all latitudes, at all attitudes, and under conditions of radar and radio silence.

(106) "AN" CONNECTOR SPECS. Hermetic Seal Corp. Catalog No. 657C, 16 pp. Contains all the information necessary for selecting and specifying this company's glass-to-metal AN connectors for military and commercial applications. Includes photos and drawings of various shell sizes and insert configurations for aircraft, communications, electronic controls, and instrument applications.

(107) TRANSISTOR ANALYZER. Norden-Ketay Corp. Bulletin BCT-300, 4 pp. Describes the special features of a new transistor analyzer and lists some typical applications. A block diagram shows the variety and flexibility of test functions as well as specifications and photos of the operating controls.

(108) POT SELECTOR CHART. DeJur-Amsco Corp. This large, 8¾-in. plastic-coated circular chart has an inner rotating wheel that presents mechanical and electrical specifications of the manufacturer's complete line of precision pots. Reverse side of the selector gives detail specs on the various elements.

(109) PLASTICS STOCK CATALOG. Allied Plastics Supply Corp. 1958 Catalog. 76 pp. The roster of stock materials included in this new catalog and price list includes vinylite, acetate, polystyrene, and polyethylene, in all shapes and sizes. Special compositions of teflon, nylon, and Kel-F are also offered, as well as a complete fabrication service.

(110) INDICATING AMPLIFIERS. Leeds & Northrup Co. Data Sheet ED7(1), 2 pp. Gives examples of applications of a new stabilized dc voltage and current-indicating amplifier. Complete specifications are listed, and the operation of the amplifier is explained with the aid of schematic diagrams. The meters and meter connections are illustrated.

(111) SENSITIVE AND POWER RE-

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LAYS. The Five Star Co., Inc. Leaflet, 4 pp. On sensitive relays, the characteristics described cover contact data, operating coils, insulation, terminals, endurance, weight, and of course sensitivity. Similar data are given on the power relays, with more attention to the operating coils. Dimensioned drawings included.

(112) FOR PNEUMATIC CONTROL. Hagan Chemical & Controls, Inc. Bulletin No. MSP-141, 6 pp. Describes this company's newly designed line of ring balance recorders, indicators, and controllers. Uses an arrow and caption treatment to explain the many proprietary features incorporated in the instruments. Also of help is a full-page table of applications.

(113) THERMISTOR BASICS. Victory Engineering Corp. Article (first of a series), 4 pp. "Meet the VECO Thermistor" series starts off with a chapter devoted to fundamentals in the use of thermistors. Also discussed is the meaning of temperature coefficient, and how the coefficient can be used to advantage. Basic dc circuit diagrams are included.

(114) MINIATURE CONNECTORS Glendale Div. of Consolidated Electrodynamics Corp. Bulletin 4003, 4 pp. plus price list and order form. Contains a general description of the company's line of high performance miniature electrical connectors. Specifications, tabulated dimensions, and ordering information covered.

(115) TUBE ANALYZER. Rheem Mfg. Co. One sheet. Briefly describes the design and application of the Rheem REL-1001 Automatic Tube Analyzer. This unit will perform any combination of 19 basic tests using the programmer principle. Both physical and electrical specifications are presented.

(116) FRACTIONAL HP MOTORS. Bodine Electric Co. Bulletin, 12 pp. Lists and describes 265 standard stock reducer and nonreducer motors of various types and sizes. Horsepower ratings of motors listed range from 1/7 to 1/1,500. Reducer motors, with speeds ranging from 833 to 0.7 rpm, have torques of 12.8 oz-in. to 219 lb-in.

(117) RELIABLE CHROMATOGRAPH. Consolidated Electrodynamics Corp. Bulletin 1836A, 10 pp. Easy but interesting to read, this bulletin covers the type 26-202 process chromatograph, a simple, reliable analytical instrument for vapor phase chromatography in process plants. Both the analyzer and the control are described separately, as are the operating characteristics and principle features.

(118) "AIRBORNE COMPONENTS". G. M. Giannini & Co., Inc. Catalog, 56 pp. Well-executed, this new catalog contains complete information on the company's full line of high-performance transducers. Sections are included on these instruments: accelerometers, pressure transducers, gyros, temperature probes, and vane transducers. A technical data section contains valuable and previously unpublished data.

(119) BTU METER. Air Conditioning Equipment Corp. Bulletin 1000. Describes a completely mechanical instrument that measures heat in thermal units and liquid flow in gallons with high precision. Construction and operation of the meter are fully described, and selection data on size, pressure, and temperature ranges given.

(120) INDUSTRIAL CONTROLS. Allis-Chalmers Mfg. Co. Bulletin 14B8615, 12 pp. Loaded with photos and drawings, this booklet covers a complete line of motor starters in sizes 4, 5, and 6, 50 to 400 hp. The patented ACBO Arc Centering Blowout for quick arc quenching is described in detail.

(121) STANDARD MOTORS. Sterling Electric Motors, Inc. Brochure, 12 pp. Illustrates several electric motor applications and contains selection data on enclosures, mountings, torque characteristics, and electrical characteristics. Some of the unusual design features of this line are gone over in detail.

(122) STEPDOWN TRANSFORMERS. Acme Electric Corp. Bulletin SD-311, 4 pp. Lists stock sizes, specifications, and dimensions of a line of stepdown transformers for a variety of applications.

(123) JET EXHAUSTERS. Schutte & Koerting Co. Bulletin 4P, 16 pp. Describes a complete line of single- and multi-nozzle water jet exhausters, water jet laboratory vacuum pumps, and barometric hydro-vac exhausters for pump priming, air handling, and evacuating vessels, and for mixing gases and liquids in continuous processes. Bulletin includes application, construction, and operation information on each type of exhauster, and gives complete rundown on sizes.

(124) DATA PROCESSING. Systems Div. of Beckman Instruments, Inc. Bulletin 3010, 8 pp. Outlines to some extent the economics of automatic data processing in the present-day well-instrumented plant, and describes the application of highly reliable equipment.

(125) PICKOFF & SECTOR POTS. Norden-Ketay Corp. Bulletin No. 415, one sheet. Gives typical specifications and outline drawings of the maker's line of sector potentiometers for aircraft and missile control systems. Units are designed to operate in damping fluids, and in temperatures in excess of 150 deg C.

(126) PANEL METERS. Waters Mfg., Inc. Catalog, 16 pp. Provides dimensional details and performance specifications for D'Arsonval-type ammeters, millivoltmeters, and voltmeters, as well as ac rectifier-type microammeters, milliammeters, and voltmeters. Instruments described are housed in a variety of plastic and metal

cases. Data on custom meters are also included.

(127) SERVO ACTUATOR. Lear, Inc. Product Data 111-3, one sheet. Describes the construction and operation of the Series 3061 servo actuator and includes typical performance curves on the unit. Features pointed out are flat packaging, fast response, high torque, and ease of installation. Engineering data and a typical installation drawing follow the outline of features.

(128) MINIATURE MOTORS. Globe Industries, Inc. Bulletin No. 110, 20 pp. This looseleaf catalog describes four basic models and sizes of ac hysteresis synchronous and induction motors. Units covered operate on ac with voltages up to 200 volts, 400 or 60 cps, one-, two-, or three-phase. Geared outputs range to 2,000 oz-in. Performance, MIL specs, and other technical data given.

(129) GAS DETECTOR. Hunter-Bristol Corp. Bulletin, 4 pp. Briefly describes a new combustible gas detector originally manufactured in conjunction with gun gas tests. The new model will handle any type of hydrocarbon, including that given off by the latest jet engine fuels.

(130) STEPPER MOTOR. Stepper Motor Corp. Bulletin, 2 pp. Presents details on the actual performance of the company's high-speed incremental or stepper motor. A dimensioned drawing is included, as well as a list of environmental conditions that the unit will withstand.

(131) PHOTOCELLS. Ess Instrument Co. Bulletin No. 570, 6 pp. Spells out detail applications of Ess miniaturized "electric-eyes", presents drawings and capsule descriptions of typical installations to point up versatility. Information on light sources, photo-units, control relays, and dimensions.

(132) MIL SPEC TIMERS. Automatic Timing & Controls, Inc. Engineering Data Sheet No. 5, 4 pp. Describes two basic types of new timers, giving applications, operation, and specifications. Diagrams show typical reset cycles, one with up to six available load circuits, another with up to five load circuits.

(133) PNEUMATIC DRIVE UNITS. Copes-Vulcan Div., Blaw-Knox Co. Bulletin No. 1033, 4 pp. Describes a line of pneumatic power-drive units for the remote operation and positioning of valves, dampers, louvers, rheostats, vanes, and variable-speed drives. A table of sizes, torque ratings, torque-output curves, and dimensional drawings provide sufficient design data.

(134) VALVE DATA. Conoflow Corp. Bulletin HB-6, 8 pp. This well-illustrated booklet gives construction details, general specifications, and operating characteristics of Series HB Saunders Valves. It contains valuable data and a comprehensive listing of flow coefficients to aid in the proper selection of valves.

(135) ELECTRONIC CONTROLS. The Bristol Co. Bulletin No. P1271, 4 pp. Describes and illustrates a new line of small-size, self-balancing electronic potentiometers and bridges. Shows three basic circuit types that can be equipped with a retransmitting slidewire or alarm contacts, or arranged for two- or three-position electric control.

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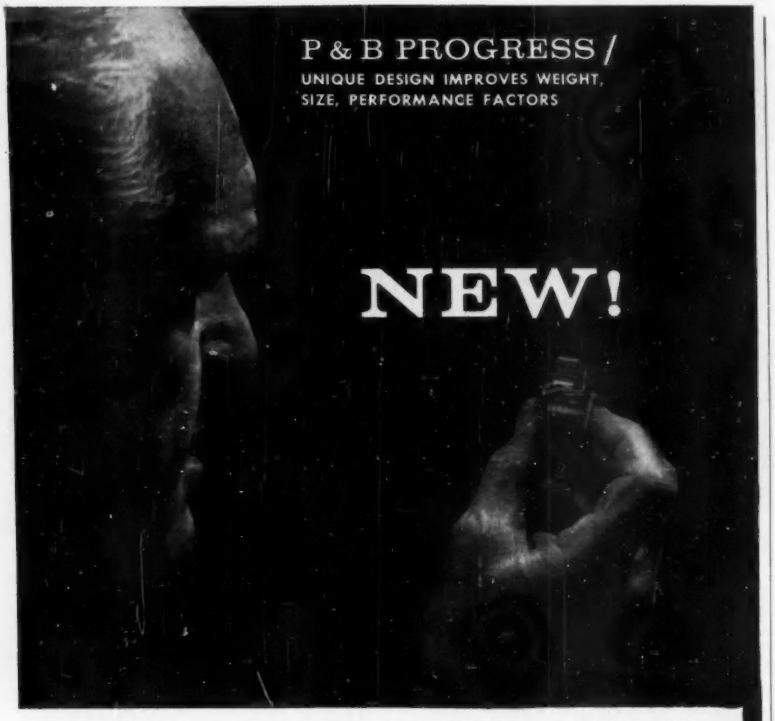
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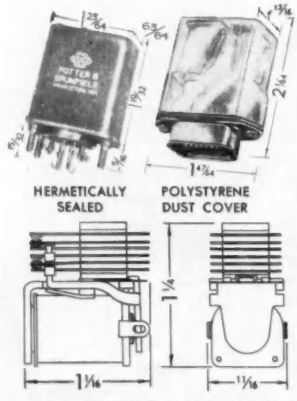


MINIATURE TELEPHONE TYPE RELAY HAS SUPERIOR SHOCK/VIBRATION RESISTANCE

Unusual for a telephone type relay, the MG Series has excellent stability under high shock and vibration conditions. Tests show this miniature, light weight (only 1.2 oz., open) relay withstands vibration of 10g 55 to 500 cycles per second and will operate under shock to 30g according to Mil-R-5757C.

The superior performance of the MG is due in part to its unique single stack construction and to an exclusive hinge design which provides zero heel gap.

Open, dust covered or hermetically sealed, the MG is available with contact arrangements up to 4 Form C (4PDT). It is rated for ambient temperatures of −55°C to +85°C. A high-temperature version with a range of −65°C to +125°C will soon be available. Write or wire today for complete specifications and delivery information.



MG RELAY

TERMINALS:
Open Relay: Pierced Solder Lugs.
Contacts: Two #18 AWG wires. Coil: Two #20 AWG wires.
Hermetically Sealed:
Miniature plug-in header with 7, 9 or 14 pins. Multiple Solder header with hook and terminals for three #20 AWG wires.
Polystyrene Dust Cover: Micro Ribbon plug-in type.
Mating receptacle: Amphenol #57-20140 or similar.
INSULATION RESISTANCE: 100 megohms min.
VIBRATION: .065" excursion 10-55 cps. 10g 55-550 cps. upon request.
SHOCK: 30g according to Mil-R-5757C upon request.
TEMPERATURE RANGE: −55°C to +85°C.
WEIGHT: 1.2 ozs. (open) 2.0 ozs. (sealed).
PULL-IN SPEED: Approximately 15 ms at nominal voltage.
DROP-OUT SPEED: Approximately 10 ms at nominal voltage.
CONTACTS: 3/32 silver.
CONTACT ARRANGEMENT: 4 pole, double throw (4 Form C).
COIL POWER: 3 watts max. DC @ 25°C. Continuous duty.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC, ELECTRICAL AND REFRIGERATION DISTRIBUTORS

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PRINCETON, INDIANA

SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY
Manufacturing Divisions also in Franklin, Ky. and Laconia, N. H.

APPLICATION LITERATURE

(140) SAFETY CONTROLS. McDonnell & Miller, Inc. Booklet, 24 pp. Entitled "Basic Safety Controls for Low Pressure Steam Boilers", this new booklet was designed as a companion piece to one previously issued on safety controls for hot water space heating boilers. The new book follows the same basic pattern: tells the story in simple diagrams, wastes no



words on product description, adheres to the "why" and "how" of all authoritative methods for providing maximum safety and automatic water level control for all low-pressure steam boilers. Each case is fully, yet briefly, covered. Examples range from the small domestic boiler to multiple boiler installations.

(141) PNEUMATIC CONTROL THEORY. The Bristol Co. Bulletin A130. 44 pp. This brand new two-color bulletin features more than ten pages on automatic control theory. It illustrates and describes in simplified terms the basic concepts of narrow band, proportional, reset, derivative, and reset plus derivitive control actions. Selective, cascade, and ratio control are also covered.

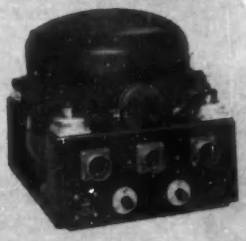
(142) VAPOR FRACTOMETERS. Perkin-Elmer Corp. Brochure, 24 pp. In general, this new bulletin contains more product description than application data, but it has been included in this column



because of the current interest in analysis instrumentation. Product descriptions, incidentally, are fairly thorough and are accompanied by well-executed flow schematics. Special features of each model are pointed out. Four pages on columns and column performance follow a discussion of the application of the Model 188.

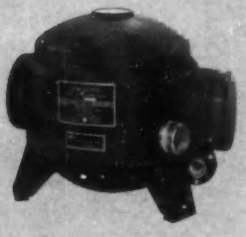
PERFORMANCE PROVES CAPABILITY

INERTIAL GUIDANCE



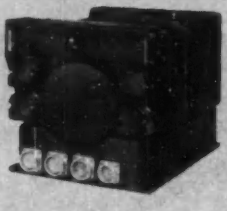
KEARFOTT has been engaged in the development, production and flight testing of Inertial Systems and their components for over 7 years. Their leadership in the field of lightweight, high precision Inertial Guidance Systems for aircraft and missiles has been proved by performance. The instrument shown here is a typical KEARFOTT inertial platform.

CENTRAL GYRO REFERENCE SYSTEMS



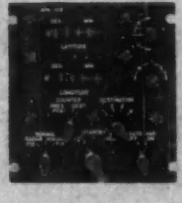
Based on this 3 gyro, 3 gimbal stable platform weighing only 25 pounds, precise vertical reference (2 milliradians) under all dynamic conditions is guaranteed. This system also serves as an all-latitude compass system with 1° per hour random drift rate. Its performance is substantiated by the hundreds of systems in operation today.

LIGHTWEIGHT ALL ATTITUDE COMPASS AND VERTICAL REFERENCE SYSTEMS



Based on a 29.5 pound 3 gyro, 4 gimbal platform, Kearfott All Attitude Compass Systems provide continuous steering signals throughout a LABS maneuver. In addition to the compass features of the U.S.A.F. J4 System, precise vertical reference for fire control, autopilot and radar stabilization is available. Proved by 2 years' service in the field. Total system weight—57 pounds.

GREAT CIRCLE NAVIGATION COMPUTERS



Kearfott's great circle dead reckoning computer systems, continuously compute and display present position, course and distance to a primary and 3 alternate destinations, latitude and longitude of the destination points. Ground track is also indicated. Range: 2000 miles, speed range: 2000 knots. Extensive flight tests have confirmed the following accuracies: Present position—1 mile or ½% of distance traveled; Distance—1 mile or ½%; Course: ½°.

COMPONENTS:

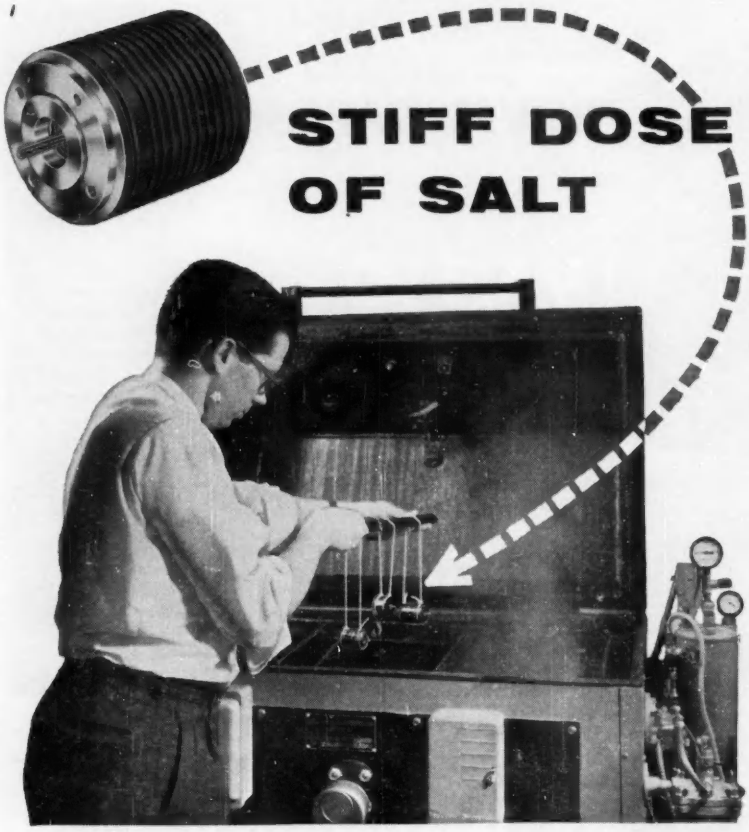
Only the dependable accuracy of KEARFOTT Components have made the dependably accurate KEARFOTT Systems possible. KEARFOTT Components include Synchros, Servo Motors, Tachometers and computer assemblies. Their capability has been proved by years of satisfactory service in airborne fire control, autopilot, radar and navigation systems. Write today for descriptive technical data.

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WHAT'S NEW

(Continued from page 62)

other men: Thomas C. Searle, formerly a fellow assistant director of the laboratory and before 1952 with the Air Force Research Center at Cambridge, who becomes vice-president; Carl G. Blanyer, formerly assistant supervisor of the Systems Engineering Div. of the laboratory; James L. Coakley, who was supervisor of the Fluid Power Control Div.; Hans A. Hug, who joined the laboratory as a research engineer after previous work in his native Switzerland and in this country; Hideo Mori, a specialist in analog computation and systems analysis who has been technical aide to the laboratory director since 1956; and Peter G. Pantazelos and Franklin C. McCoy, who become secretary and treasurer, respectively.

In addition, two men on the MIT faculty will serve Hydel as consultants. They are John F. Blackburn, research associate in the Mechanical Engineering Dept., and William W. Seifert, associate director of the Dynamic Analysis & Control Laboratory and associate professor in the Electrical Engineering Dept.

Brake Shoe, incidentally, has just elected a new vice-president. He is William C. Denison, president of the Denison Engineering Div. and a pioneer in the development of hydraulic power. Denison also joins the parent company's Operations Policy Committee and will be another Brake Shoe executive accessible to the team at Hydel.

Control Data Corp. to perform research and development work in data processing, instrumentation and controls—in Minneapolis. Behind the company organization is its first president, William C. Norris, who was one of the founders of Engineering Research Associates and most recently was vice-president and general manager of the Remington-Rand Univac Div.

Shortly after he announced he was in business, three other Univac men left Rem-Rand to join Norris in the new enterprise. They are: Frank C. Mullaney, formerly director of military systems engineering, named director of engineering; James G. Miles, formerly director of special sales, named director of engineering services, and Willis K. Drake, formerly assistant to the general sales manager, named marketing director. A fourth new exec, Arnold J. Ryden, most recently operated his own management com-

At Moog:

Production Valves

Quality Tested

One reason Moog makes so many servo valves so well is just what you see here—a superbly-equipped test room where every valve is put through its paces. All test apparatus was designed and built by Moog especially to test production valves for performance criteria including flow rate, frequency response, resolution, linearity, and hysteresis. This attention to quality in quantity is your assurance of reliable servo valves for your production requirements.



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Research Laboratory, Paramus, New Jersey

careers in peaceful applications of atomic energy

ENGINEERS–
SENIOR POSITIONS

Diversified work in overall reactor analysis

SYSTEMS/CONTROL–ANALYSIS

Qualifications: BS, MS, PhD in EE, Physics or Nuclear Engineering. 1-3 yrs. experience reactor or control systems evaluations, or related instrumentation.

Duties: Direct and perform stability analysis. Develop power plant control systems. Prepare system specifications, and perform nuclear hazard evaluation of reactor systems.

REACTOR ANALYSIS

Qualifications: BS, MS in Engineering. Prefer minimum 4 years' experience in related field.

Duties: Analyze, direct engineering efforts on advanced reactor plant design. Special emphasis on overall plant control, steam plant operation and economic analysis of integrated reactor steam plants.

Write: Answer will be prompt, confidential.

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A DIVISION OF NORTH AMERICAN AVIATION, INC.

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21600 Vanowen Street, Canoga Park, California
(In the Suburban San Fernando Valley, near Los Angeles)

WHAT'S NEW

pany. At Control Data he will be vice-president, secretary, and treasurer.

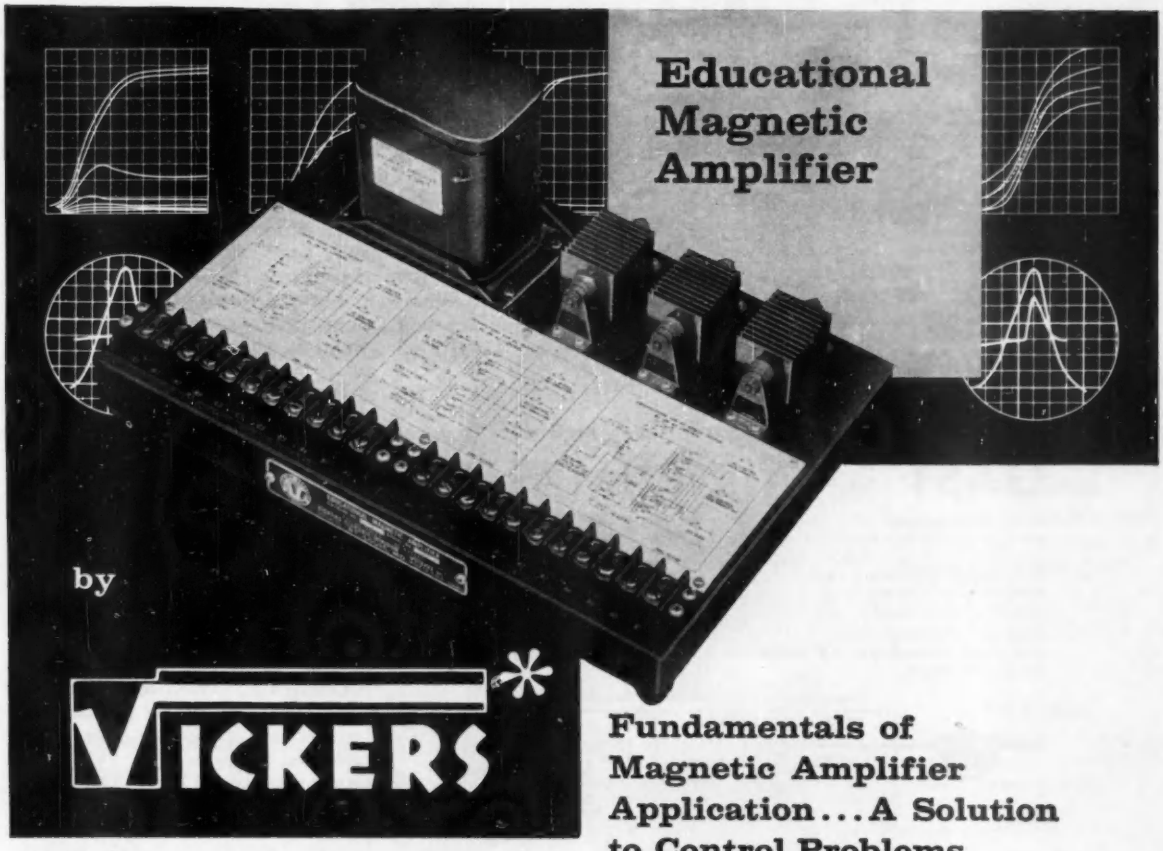
The new company does not expect to compete in the production of large-scale computers, Norris said. Instead, it will complement the builders of these systems as a developer of selected components. Among them: recorders, translaters, and converters. It will also offer advice to businesses on selection of electronic equipment.

Controls for Radiation, Inc., formed with the intention of carrying out a complete program of monitoring on an independent basis–in Cambridge, Mass. The "package" service, says President William E. Barbour Jr., who is founder and former head of Tracerlab, Inc., is geared to a promised "rate of growth in the use of nuclear reactors, intense radiation sources, and by-product radioactive isotopes which is unprecedented for any new industry in modern times." Nuclear reactor operators, fuel fabricators, reprocessors of uranium fuels, users of radioactive materials and particle accelerators, and radioactive waste disposal groups all fit into CR's protection scheme.

The new company will lease and maintain instrumentation for monitoring radiation at or near nuclear facilities, periodically evaluate commercial instruments, establish radiation protection programs, and train personnel in the fundamentals of radiological safety and in solving decontamination problems. It will also make radiometric, mass spectrographic, and fluorimetric analyses of reactor fuels to determine fissionable material content.

Auerbach Electronics Corp., made up of specialists in the application of data processing techniques and headed by the former director of the Special Products Div. of Burroughs Corp.–in Narberth, Pa. Isaac L. Auerbach, the ex-Burroughs man, designed the first static magnetic memory system for the ENIAC computer at Aberdeen Proving Ground, and developed the mercury memory and construction method for the BINAC and UNIVAC systems. He and his team of engineers and scientists will apply DP methods to industrial process control, telemetering, automatic test equipment, digital communications, and numerical machine tool control.

National-El Ray Co., the result of a merger of makers of miniature ac and dc motors, ceramic capacitors, and filters, transformers, and airborne electronic heating elements–in North Hollywood, Calif. The component companies are El Ray Motor Co.,



*TRADEMARK

Fundamentals of Magnetic Amplifier Application... A Solution to Control Problems

For industry and schools, for experimental work and basic instruction in the principles and characteristics of high-performance, self-saturating Magnetic Amplifiers in control applications.

With automatic control playing an increasingly bigger role in our rapidly advancing industry, the magnetic amplifier has become a key component of industrial and military control systems.

To help engineers, students, and laboratory personnel understand magnetic amplifier principles and performance, Vickers has designed and has available this unique instrument. Permits the study of all basic single-phase magnetic amplifier circuits employing either d-c or a-c control and output. Can be used as an experimental control circuit in actual specific applications.



Each Vickers Educational Magnetic Amplifier includes these helpful training aids (left): the Vickers Magnetic Amplifier Laboratory Manual, and the Vickers Magnetic Amplifier Application handbook.

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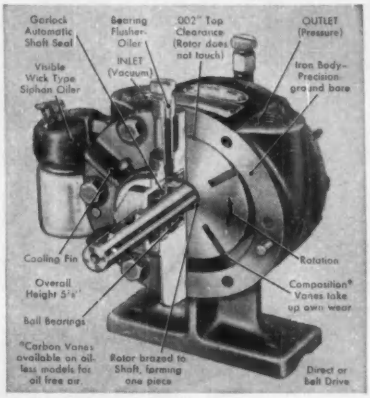
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NEW! Model 226A
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OUTSTANDING FEATURES:

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Three independent, adjustable trigger level controls permitting full rated sensitivity at any voltage level between —300 and +300 volts.

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Simplified color-coded controls and direct read-out in kc, mc, sec, or millisec, with automatic decimal point indication.

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Oscilloscope marker signals facilitate start and stop trigger level adjustment for time interval measurement of complex waveforms.

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CC-29

WHAT'S NEW

Valco Engineering Corp., and National Electronics Corp. John N. Valianos is president, Lee Valianos executive vice-president, Kim Demetriou vice-president for engineering, and Tony Moriales assistant chief engineer.

Silicon Crystals, Inc., grower and supplier of silicon crystals and other semiconductor metals for manufacturers of silicon diodes, rectifiers, and ficers are A. J. Gordon, formerly president of Gordon Chemicals, Inc., president, and John E. Herman, formerly with du Pont.

Leeds & Northrup, Canada, Ltd., organized as a wholly-owned manufacturing subsidiary of Leeds & Northrup Co.—in Toronto. Better L&N service for Canadian customers is the idea behind the new company, whose president is J. William Robinson, formerly coordinator of western operation for the parent concern.

Conap Co. formed to conduct research and development in the combination and application of synthetic materials, by Russell M. Houghton, former president of Houghton Laboratories, Inc.—in Olean, N. Y.

Industro Transistor Corp. to manufacture germanium alloy-junction (NPN and PNP) transistors for computers, audio equipment and radios—in Elmhurst (L. I.) N. Y.

Reltron Corp. to manufacture high temperature subminiature relays by a process that heremetically isolates coil assembly from contact assembly—in Newton, Mass.

Zahorski Engineering, Inc. to perform research and development in structures, electronics and mechanics, particularly as associated with elevated environmental conditions in aircraft and missiles—in Santa Barbara, Calif. One prime project involves the development of hydraulic analog instruments for the determination of a pattern of heat flow throughout a structure; another is the design of pressure pick-ups and related instrumentation for operating at temperatures of 1,000 deg F. First president is aviation industry veteran Dr. Adam Zahorski, who has been associated with Northrop Aircraft, North American Avia- and Lockheed Aircraft Co.

New Divisions and Groups

Nortronics Div. to handle mounting work at **Northrop Aircraft** on new electronic, electromechanical and optomechanical products and components.

Simplify control problems...

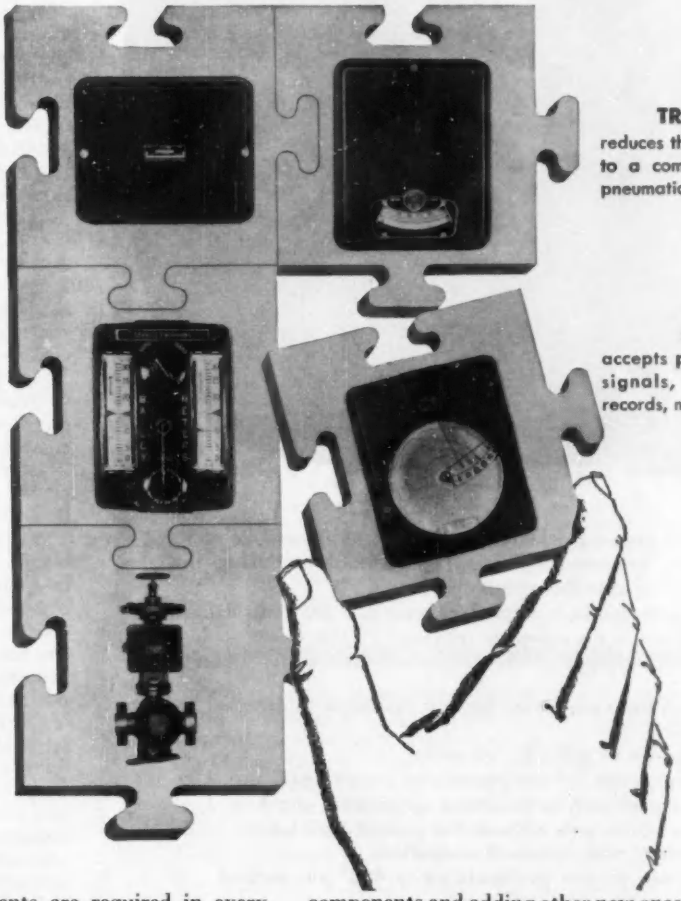
with the Bailey Building Block Method

Control problems are greatly simplified when you attack them using the Bailey Building Block Method. In a nutshell, the method consists of using standard components that fit together like building blocks. Virtually any control requirement can be handled by selecting standard components. Here are the parts you use and the functions they perform.

CONTROL RELAY
takes signals from the transmitter and computes corrective action in terms of pneumatic signals.

SELECTOR STATION
gives operator choice of hand or automatic control including set-point or bias adjustments.

POWER UNIT
is the "muscle" of the system. It performs whatever precise mechanical action is necessary to achieve control.



TRANSMITTER
reduces the measured variable to a common denominator, a pneumatic or electric signal.

RECEIVER
accepts pneumatic or electric signals, indicates and/or records, measurements.

Not all these components are required in every control system. You buy only what *your* system needs. When you change processes or add more automatic control, you can add additional standard components. Sometimes you may want to build a whole new system, re-using some of the existing components and adding other new ones. Spare parts inventory and maintenance training are reduced.

Hear the complete story of the Bailey Building Block System. Find how it can solve your control problems. See your Bailey Engineer or write for more information. G44-1

BAILEY BUILDING BLOCK METHOD

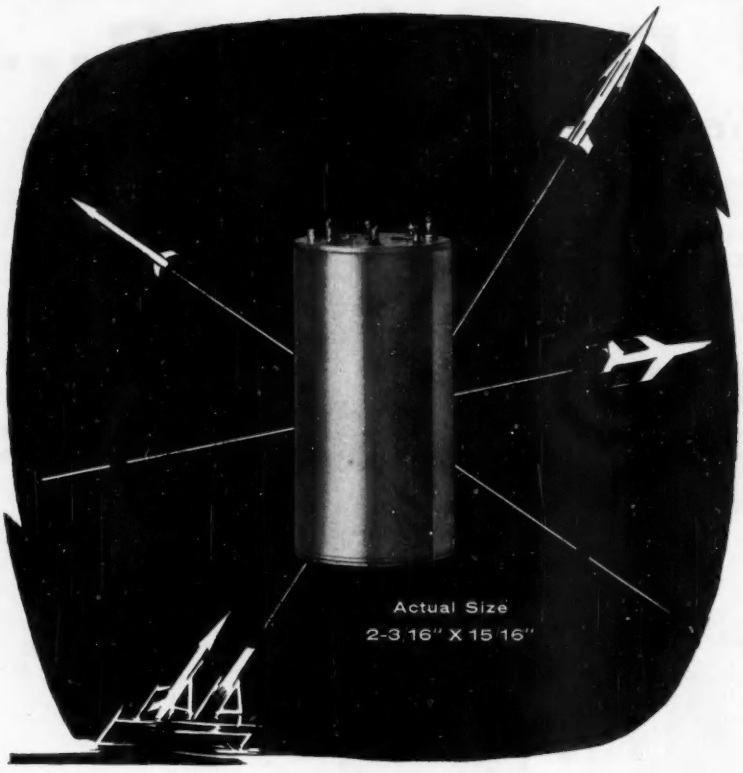
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BAILEY METERS

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SANDERS Subminiature RATE GYRO



To meet the growing demand for reliable control and stabilization elements, Sanders Associates is now mass-producing the Sanders sub-miniature rate gyroscope.

Exacting applications in aircraft, missile and fire control have proved conclusively the complete reliability of this rate gyro in a wide range of conditions and environments. Its features include:

- **Torsion bar suspension for fast response to minute signals**
- **Resolution of 0.001% full scale**
- **Compensated for environmental conditions**
- **Fluid cushioning to minimize vibrational shock**
- **Rotary multi-pole differential pickoff for higher sensitivity and excellent resolution**
- **Full scale ranges available up to 400° per second**

Sanders' direct distribution offers the long experience of Sanders engineers. Their assistance can be invaluable in reviewing your gyro design and application problems. Whether your problem is on selection of a gyro or a complete gyro control package, our Application Engineers are available to serve you.

SANDERS ASSOCIATES INCORPORATED Dept. F, NASHUA 11, NEW HAMPSHIRE

West Coast Field Office: 1608 WEST CENTINELA BLVD., INGLEWOOD, CALIFORNIA

WHAT'S NEW

William F. Ballhaus, formerly vice-president and chief engineer of the Northrop Div., was elected a company V-P and given general manager supervision over the new division. His successor in the Northrop Div. is George Douglas, formerly assistant general manager, named vice-president for engineering. Roy P. Jackson, formerly assistant chief engineer in the same division, has been elevated to chief engineer.

Analytic Systems Co., a divisional offshoot of **Research Instrument Corp.,** which will develop, manufacture, and sell process stream analysis instruments and furnish complete analysis systems. Alfred D. Robinson is research director and Robert W. Negus is chief engineer.

Allis-Chalmers International, formed as a major operating division with responsibility for all **A-C** manufacturing, engineering, and sales operations outside the U. S. and Canada. Managing director is P. F. Bauer, formerly general manager of the Industrial Equipment Div. of the parent company.

An Electronic Components Div., to develop and manufacture specialty transformers and other electronic components for **ESC Corp.** In charge is John F. Nielsen, formerly manager of the Transformer Dept. of Allan B. DuMont Laboratories.

A Nuclear Power Div., formed by **Hagan Chemicals & Controls, Inc.,** to apply Hagan instruments and control methods to reactors. The new division thus links hands with the company's Hall Laboratories and Calgon divisions, already at work on water-treating problems in reactors.

Clary Dynamics Div., result of the consolidation of the Aircraft and Automatic Controls divisions of **Clary Corp.** Products coming out of the new division include pressure regulators, hydraulic valves, fuel valves, gyroscopes, servo-actuators, rocket-engine valves, and high-pressure valves.

An Instrument & Test Equipment Div. in **Jerrold Electronics Corp.,** to channel the company's new electronic coaxial switch, field strength meter, oscilloscope preamplifier, and its line of sweep generators, rf attenuators, and accessories. Caywood C. Cooley, an engineering vice-president, is in charge.

Fattenings

Cleveland Meters, Ltd., of England (water meters, industrial liquid meters) by **Neptune Meters, Ltd.,** of Toronto,

which during the last five years has jockeyed itself into an enviable spotlight by acquiring: Electronic Signal Co., Inc.; Cox & Stevens Electronic Scale Co.; Revere Corp. of America; Superior Meter Co.; and (50 percent only) Hotspur Detector, Inc. Arthur Hargreaves, formerly technical director of Cleveland Meters and now its managing director, will supervise it at its location in Redcar, Yorkshire, England.

Cumberland Optical Co. of Silver Spring, Md. (cylinderical lenses, penta prisms, wind-tunnel windows, grating blanks, optical flats, etc.) by **Atlantic Research Corp.**

Rahm Instruments, Inc., of Westbury, N. Y. (electromechanical instruments for aircraft and missiles) by **American Machine & Metals, Inc.**, which will operate Rahm as a division in its instrument plant at Sellersville, Pa.

Maryland Electronic Mfg. Corp. of College Park, Md. (air navigation aids, radar microwave antennas, telemetering equipment) by **Litton Industries.** Maryland's William R. Morse stays on as president and chief operating head.

Vard, Inc., of Pasadena, Calif. (electromechanical equipment for the aircraft industry) by **Financial Holding Corp.**, whose president, former Ford Motor Co. production man John A. Swint, becomes president of Vard. Swint has brought [illegible] another former Ford man, Herold J. Morris, as vice-president for engineering, but has retained most Vard executives.

Contracts in Control

• **Army**—A photographic mapping radar system ($1,394,318) to Texas Instruments, Inc., and closed TV systems for monitoring tests at Huntsville, Ala., and Denver, Colo. ($300,000) to the Hallamore Electronics Div. of The Siegler Corp.

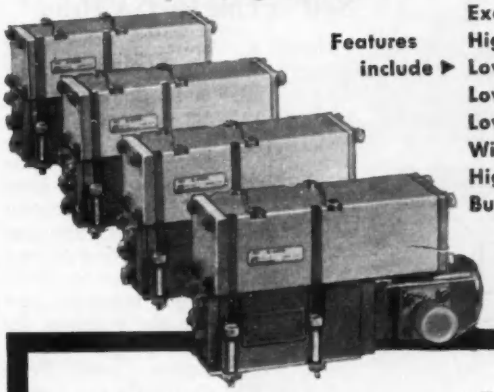
• **Air Force**—An all-attitude flight-control system to assist the pilot of a classified aircraft ($1,298,518) to Sperry Gyroscope Co.; passive electronic equipment ($17,528,850), and airborne radio beacons ($1,259,399) to Stromberg-Carlson Div. of General Dynamics Corp.

• **Others**—A control system for two wind tunnels ($85,000) to CDC Control Services, Inc., from Republic Aviation; electronic instrumentation for a comprehensive test-range system ($400,000) to Consolidated Electrodynamics Corp. from Interstate Electronics Corp.; and a new barometric altitude controller ($1,894,000) to Servomechanisms, Inc., from Hughes Aircraft.

Now in mass production . . .

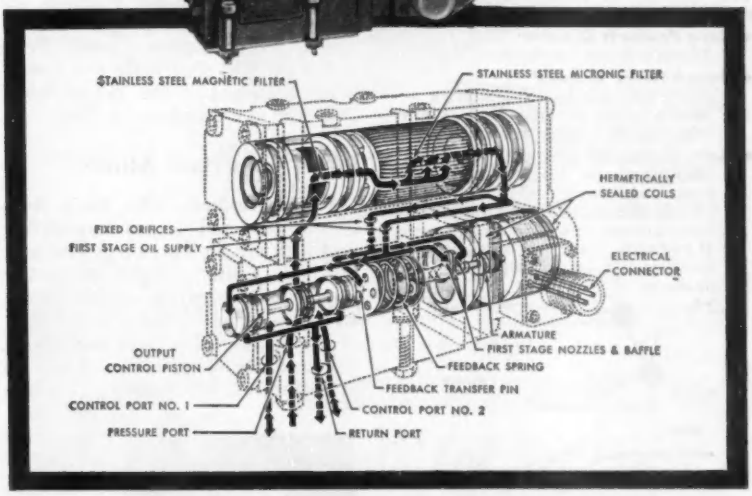
SANDERS SA-19 SERVO VALVE

The Sanders SA-19 Servo Valve provides unparalleled efficiency and reliability for a wide variety of electro-hydraulic components and systems. Utilizing the Sanders internal force feedback principle, this two-stage electro-hydraulic amplifier develops large hydraulic output flows with relatively low input electrical power requirements.



Features include ▶

- Excellent Resolution
- High Power Amplification
- Low Hysteresis
- Low Threshold
- Low Input Power
- Wide Frequency Response
- High Stiffness of Control
- Built-in Filtration



Operation: An input current, converted to a magnetic force in the First Stage Armature, moves the First Stage Baffle between two nozzles causing a pressure differential across the ends of the Output Control Piston. The resulting motion of the Output Control Piston is fed back through the Transfer Pin and Feedback Spring as a restoring force on the First Stage Armature, thus nulling the valve and porting oil to the load. The First Stage Oil Supply is thoroughly filtered as shown.

TYPICAL SPECIFICATIONS:

Coil Resistance (ohms/coil) 3000	Amplitude Ratio within 3 db at 100 cps
Differential Current ±20 ma	Phase Shift 90° at 100 cps
Flow (GPM @ 1000 psi across valve) 8	Resolution (% of Full Signal) ±0.2
System Pressure (psi) 3000	Hysteresis (% of Full Signal) ±3.0

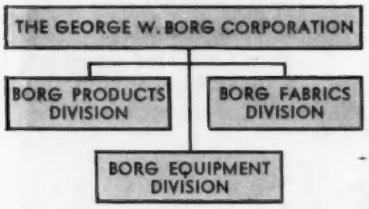
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West Coast Field Office: 1608 WEST CENTINELA BLVD., INGLEWOOD, CALIFORNIA

WHO IS BORG?

George W. Borg, who founded this corporation, is the "Mr. Clutch" who started with Borg & Beck. He then helped organize the Borg-Warner Corporation of which he became president. Later he served as chairman of the board until he resigned to devote his full attention to The George W. Borg Corporation.



The George W. Borg Corporation is comprised of three divisions

- **Borg Products Division**
  Manufactures automotive clocks.
- **Borg Fabrics Division**
  Manufactures deep-pile fabrics best known of this line is the fashionable "Borgana" fabric.
- **Borg Equipment Division**
  Manufactures Micropots (precision potentiometers), Microdials (precision turn-counting dials), instrument motors, frequency standards, aircraft navigational instruments and components for systems.



HOW BORG EQUIPMENT DIVISION CAN HELP YOU . . .

Borg's background of experience will save you time and money by helping you solve design and production problems of electronic components. Whether you are faced with a special problem or interested in a standard component, call Borg Equipment Division for an economically sound solution. Write today for catalog BED-A56.

BORG *Built by Borg*
MOTORS
MICROPOTS
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BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

IMPORTANT MOVES BY KEY PEOPLE

Latest Election Puts Frost Next in Line for ISA Helm

Henry C. Frost, assistant chief engineer of Corn Products Refining Co. since 1953 and a charter member of the ISA, is the man next in line for the presidency of the society. His election to the springboard position of president-elect and secretary came at the annual Conference & Exhibit in Cleveland in September. (See page 28 for a full report on this meeting.) Frost joined Corn Products in 1945, the year the ISA was organized, and under his direction the company designed and installed the control system for its Corpus Christi (Tex.) and Argo (Ill.) plants. He was named a vice-president of the ISA in 1947 and first vice-president in 1948.

Other Important Moves

▶ **Roe Nardone**, who takes on a directorship and a key engineering post with Haydu Electronics Products, Inc., is a leading designer of electromechanical actuators, landing gears, and other aircraft parts, and co-author of *Kent's Manual*, a basic engineering reference. His new position of director of engineering will probably take him away from much of the consulting work that has helped to make his name an important one in the electronic and aeronautical fields.

▶ **Alfred H. Grebe**, the new chief engineer for Filtors, Inc., joined the company in 1953 and up to the time of his present appointment was its head of R&D. Before 1953 he operated his own radio and television company, and prior to that was with Sperry Gyroscope.

▶ Promotion to director of R&D climaxes six years of steady rise for **Thomas P. Evans** at American Machine & Foundry Co. He joined the company in 1951 as chief electrical systems engineer and became chief electrical engineer in 1952, section manager of the General Engineering Laboratories in 1953, technical director of the laboratories in 1954, and deputy director of R&D in 1955. Before coming to AMF, he was with the Atomic Power Div. of Westinghouse (1948-51) and at Yale University as an instructor (1946-48).

▶ New chairman of Advance Industries' Technical Advisory Committee is **M. W. P. Strandberg**, an associate professor of physics at MIT specializing in microwave research. During the war Strandberg was a visit-


H. C. Frost


Roe Nardone


A. H. Grebe


T. P. Evans


M. W. P. Strandberg


Bernard Jacobs

ing scientist working on radar countermeasures at the Telecommunications Research Establishment in Malvern, England. He is a fellow of the American Physical Society.

▶General Transistor Corp. has picked **Bernard Jacobs,** formerly head of material research in Sperry Rand Corp.'s Sperry Semiconductor Div., as its first vice-president for research. Before going to Sperry, Jacobs specialized in semiconductor development at Federal Telephone & Radio Corp. and Radio Receptor Co.

▶As Pratt & Whitney's President **Edward P. Gillane** prepared to take on new duties as executive vice-president for industrial operations for the parent Penn-Texas Corp., a new man came to P&W as chief engineer of conventional gages. He is **Jay E. Watson,** an authority on gage standardization



E. P. Gillane



J. E. Watson

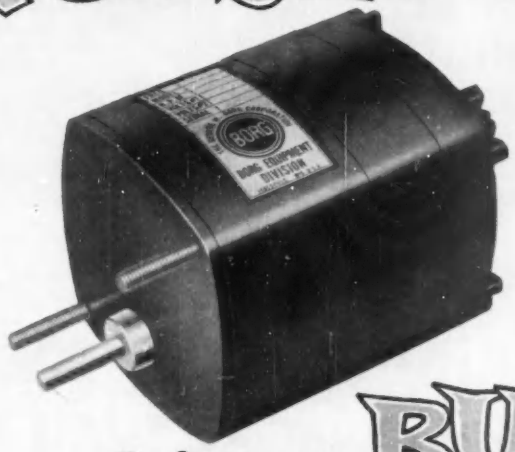
and chief of the Ordnance Gage Center at Frankford Arsenal since 1952. Gillane joined P&W in 1948 as vice-president and controller of its Potter & Johnston subsidiary. He became president of P&J in 1955 and president of P&W in 1956. Watson joined the Ordnance Corps in 1940 and in 1955 represented the Dept. of the Army at a British-American-Canadian conference on unification of engineering standards.

▶**Oskar Mattiat,** well-known both in this country and in Europe for his work in communication engineering and ultrasonics, has joined Aerophysics Development Corp., a subsidiary of Curtiss-Wright Corp. Mattiat, most recently head of the Special Devices Group at the Clevite Research Center, has also been with the center's Electric Wave Filter Section, with the AEG facility in Berlin, Germany, and with the Institute of Technology, Munich.

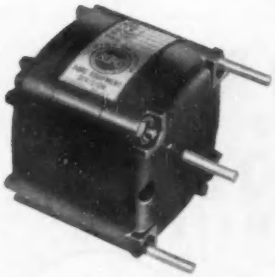
▶Supervision of the Special Products Div. will be one of **J. Vance Holdam Jr.'s** principal responsibilities as vice-president for operations at Laboratory for Electronics, Inc. One of the founders of the company, Holdam left in 1953 to become a vice-president of Tracerlab, Inc. He returned recently as assistant to the president.

▶**Leonard I. Kent,** named chief mi-

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"Does the motor have a long history of proven performance behind it?"

"Does the motor have engineering advantages that assure longer life and continued accuracy?"

"Can the motor be supplied in more than one model?"

"Can the motor be supplied to meet our specifications?"

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ELECTRONIC–MECHANICAL BORG EQUIPMENT Built By Borg

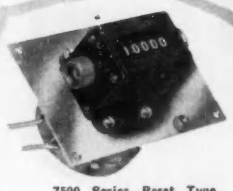
MOTORS
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the A. W. HAYDON COMPANY'S ELAPSED TIME INDICATORS

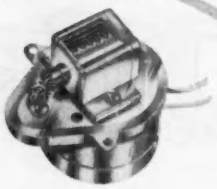
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INDUSTRIAL, AIRCRAFT and MILITARY applications

Preferred Where Performance is Paramount



7500 Series Reset Type Elapsed Time Indicator. Send for Bulletins: AWH ET601. Reset Type Elapsed Time Indicators 7500, 12500, 24200 Series.



7500 Series DC Elapsed Time Indicator. Send for Bulletins: AWH ET600. Basic Elapsed Time Indicators 7500, 12500, 24200 Series.

Now the Company offers a complete line of timing motors and devices to record the operating time of any electrical or electronic equipment. Compact, minimum weight, each unit has five digits. They can be used to provide daily running time plus a total running record, eliminating estimating or manual totalizing. In both AC and DC, continuous or manual reset for 50 or 60 up to 400 cycle line frequency. Will measure hours or on down to 10ths of seconds. All models can be supplied with Radio Interference Filtering, to meet MIL-I-6181B.



Shown at the left is the new A. W. Haydon Co. catalog describing the complete line of timing motors and devices; if you haven't received your copy write for it on your company letterhead.

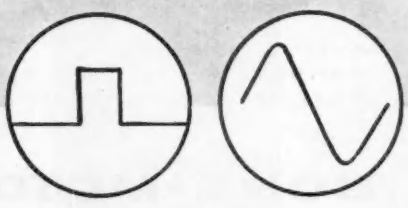
The A.W. HAYDON Company

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Design and Manufacture of Electro-Mechanical Timing Devices

TRANSISTORIZED MODULAR FREQUENCY METER





10 CYCLE TO 100KC • ± 2%

7 RANGES .....100 • 300 • 1KC • 3KC 10KC • 30KC • 100KC

INPUT .....0.1 Volt to 120 Volts

PULSE RESPONSE .....Down to 1% Duty Cycle

MODEL FM-241

$125.00

This Instrument is a ½ Module of the TLI Modular Instrumentation System and may be rack mounted with Modular Rack Adapters or stacked on a bench using the Modular Stack Pedestal.

TELETRONICS LABORATORY, INC.

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RACK STACK COMBO

WHAT'S NEW

crowave engineer for The Narda Microwave Corp., comes from F-R Machine Works, where he was a senior project engineer. Before that he was with Airborne Instruments Laboratory, Inc., Polytechnic Research & Development Co., and Espey Mfg. Co. He is completing requirements for an engineering doctorate at Polytechnic Institute of Brooklyn. Another new face at Narda belongs to **Paul M. Platzman,** a founder and former vice-president of Acoustica Associates, Inc., who will help steer the new subsidiary Ultrasonics Corp. as vice-president and sales manager.

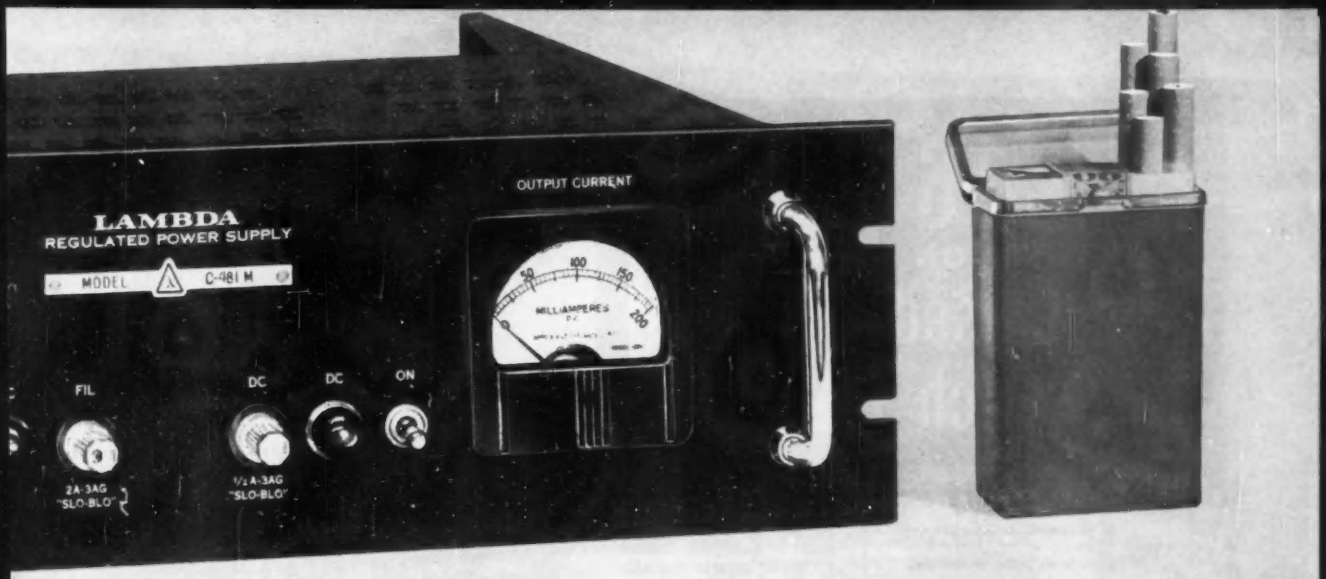
▶ New chief of the Physical Chemistry Section of the National Bureau of Standards is **Roger G. Bates,** an authority on pH measurement and a member of the bureau since 1939. He succeeds **E. R. Smith,** who retired last June. Bates is not only a prolific author (he's written more than 60 technical articles and a book), but is active in society work, too. Item: chairmanship of the Commission of Electrochemical Data, International Union of Pure & Applied Chemistry.

▶ Some of the names figuring in the recent realignment of engineering and marketing activities at Motorola's Chicago Military Electronics Center: **A. Ross Simpson,** chief engineer of the company's Forest Park, Ill., facility since 1951, appointed engineering manager; **Marlin G. Korger** raised from manager of R&D to chief engineer; **Ralph F. Waldon** elevated from manager of product engineering to chief engineer of production design and development; **Robert D. Anderson,** the new manager of engineering services; **Edmund Ross,** now manager of field engineering; **Russell A. Kasmar,** named manager of technical publications, and **Walter A. Bachman,** formerly marketing field coordinator, who becomes manager of contract relations.

▶ **Clifford A. Busse,** who has been named engineering manager of Rheem Mfg. Co.'s Electronics Div., most recently was assistant manager and chief engineer for missile test equipment in IT&T's Farnsworth Electronics.

▶ **Yasundo Takahashi,** an authority on automatic control systems and a CtE author (May '55, p. 46), has been appointed professor of mechanical engineering at the University of California at Berkeley. He has taught at several schools in Japan.

▶ Manager of the new West Coast (San Fernando, Calif.) unit of Federal Telecommunications Laboratories'



Not much taller than a pack of cigarettes...

See how much space you save with New Lambda COM-PAK® Power Supplies

THREE VOLTAGE RANGES:
0-200, 125-325, 325-525 VDC



Economically priced. 400 MA Lambda Com-Pak model (illustrated) needs only 5¼" of panel height, from $244.50 Other models include 200 MA (5¼") priced from $159.50, 800 MA (7") from $315, and 1.5 amperes (8¾") from $550.

FAST IN-RACK SERVICING

Wiring, tubes, and other components readily accessible. You can reach them easily, service them fast.



Quick rear access to tubes and controls.

Rear panel swings open for servicing.



C-200 series – 200 MA – need only 5¼" of panel height
C-400 series – 400 MA – need only 5¼" of panel height
C-800 series – 800 MA – need only 7" of panel height
C-1500 series – 1500 MA – need only 8¾" of panel height

Space-saving models available for all power supply needs up to 1.5 amperes

You get king-size performance as well as real space economy with Lambda's new Com-Pak regulated DC supplies. Completely new electrical and mechanical design. More functional – easier to combine with other components – designed for faster, handier maintenance and servicing.

400 MA and higher current range models have high-efficiency, long-life hermetically-sealed semi-conductor rectifiers. All Com-Pak models include hermetically-sealed transformers, chokes and capacitors.

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16 POSITION enclosed switch



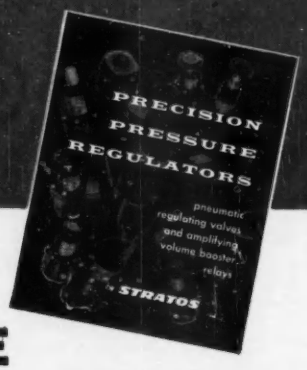
ESCO rotary multipole SWITCH

- 16 contact positions per pole.
- up to six poles, or sections.
- panel mounting.
- electrical rating—5 amperes 125 volts a-c interrupting.
- 22-½° positive detent action.
- contact resistance 0.001 to 0.005 ohms (all-silver contacts).

The ESCO Type HT rotary multipole switch provides greater versatility in an enclosed-type switch. The switching action is fully enclosed in the molded phenolic structure of each section. A single knob controls the entire assembly permitting centralized control of complex circuits. *Write today for Bulletin 6.*

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The facts you need on a complete range of pneumatic pressure regulating valves and volume boosters. Here is your guide to a series of pilot-operated and direct acting regulators—in pipe sizes from ¼ to ⅜ and ¾ NPT...in supply pressures up to 250 psi. Fact-filled pages spell out the full story: characteristics • pressure ranges, ratios • applications—for 16 different models including motor operated and lever set types.

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INDUSTRIAL PRODUCTS BRANCH
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A DIVISION OF FAIRCHILD ENGINE & AIRPLANE CORPORATION

electronic countermeasures laboratory is **Francis X. Bucher,** who will be in charge of coordinating all activities and building the staff.

▶The new director of R&D for Redel, Inc., is **Douglas C. Vest,** formerly in charge of applied interior ballistic research, Aberdeen Proving Ground, Md.

Award Committees of IRE, AIEE, Others Open Season

Fresh from their summer huddles over some of the brightest names in the field of control engineering, the award committees of the professional societies have already made known their choices for recipients of several coveted prizes. Other announcements, of course, will follow, as the new season of professional meetings moves deeper into 1958, but as things stand now, these are the men whose names will definitely be linked to awards in the coming months:

Charles S. Draper, head of the Aeronautical Engineering Dept. and director of the Instrumentation Laboratory of MIT, named recipient of the ASME's Holley Medal awarded for "a great and unique act of engineering genius". Draper won the award, last given in 1955, for what is called a revolutionary new principle for controlling guns fired from a moving platform at moving targets. First application of this principle was made to anti-aircraft systems on naval ships during World War II, and subsequently it was applied to fighter planes.

Albert W. Hull, consultant to the General Electric Research Laboratory at Schenectady, N. Y., named to received the IRE's Medal of Honor, often called the highest technical award in radio and electronics, for "outstanding scientific achievement and pioneering inventions and development in the field of electron tubes". He is credited with creating more types of electron tubes than any other man.

W. R. G. Baker, vice-president of GE, scheduled for the IRE Founders Award "for outstanding contributions to the radio engineering profession through wise and courageous leadership in the planning and administration of technical developments which have greatly increased the impact of electronics on the public welfare".

Edward L. Ginzton, professor of applied physics and electrical engineering at Stanford University, on

100-VOLT TRANSISTOR...

New high power type available



Typical Characteristics at 25° C	DT100
Maximum Collector Current	13 amps
Collector Voltage, Emitter Open	100 volts
Saturation Voltage (12 amps)	0.7 volts
Power Dissipation	55 watts
Thermal Gradient from Junction to Mounting Base	1.2° °C/watt
Nominal Base Current I_B (V_{EC} = —2 volts, I_C = —1.2 amp.)	-19 ma
Distortion (Class A_1, 10 watts)	5%

DELCO HIGH POWER TRANSISTORS

The electronics industry asked for a transistor to handle higher voltage—and here it is—Delco Radio's DT100 with maximum collector diode voltage of 100 volts. This is the highest yet, and it paves the way for a wide range of new applications. The new DT100 is an alloy junction germanium PNP transistor—normalized to retain its performance characteristics regardless of age. You can depend on the uniformity, reliability and high current handling capacity of the DT100, just as you have in the past on all of Delco Radio's High Power transistors. Write today for complete engineering data.

DELCO RADIO

Division of General Motors
Kokomo, Indiana

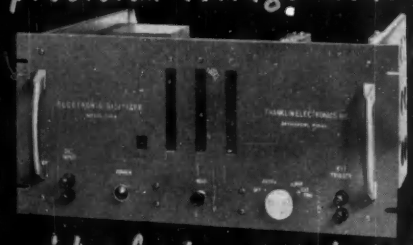
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NEW MULTI-PURPOSE DIGITIZER
for precision voltage measurement



Franklin Model 310A Digitizer

COSTS only $1975.00 F.O.B.

provides fast, accurate readings

In the laboratory or on the production line, this all electronic, multipurpose digitizer is ideal for use as an analog to digital converter, voltmeter or data reduction element. Measuring voltages from 000.0-120.0 volts DC, it provides accuracy of 0.1% of full scale and speed of 60 readings per second, automatically or on command . . . heretofore unobtainable at this low cost. Coded outputs of each significant figure in the visual readout provide a signal source to operate matrices, printers, punches, or categorizing equipment.

Also available—special DC amplifiers which convert very low voltages (microvolt ranges) to levels useable by the Model 310A Digitizer .

FEI

Franklin Electronics, Inc.
BRIDGEPORT, PA.
Electronic & Nuclear Development & Manufacturing

WHAT'S NEW

tap for the IRE's Morris Liebmann Memorial Prize "for his creative contributions to the generation and useful application of high energy at microwave frequencies".

Edward W. Allen Jr., chief engineer of the Federal Communications Commission, named by the IRE for its Harry Diamond Memorial Award "for his technical and administrative contributions in the field of radio spectrum utilization".

Charles P. Ginsburg, Ampex Corp., winner of the IRE's Vladimir K. Zworykin Television Prize "for pioneering contributions to the development of video magnetic recording".

Hull, Baker, Ginzton, Allen, and Ginsburg will receive their awards at the banquet of the IRE National Convention in New York next March. By that time, however, these men will have garnered medals and citations from other societies:

Stephen P. Timoshenko, formerly on the Stanford University faculty, to be the first recipient of the new ASME medal carrying his name. Closely identified with the ASME's Applied Mechanics Div., which the Russian-born Timoshenko helped found, the medal will be given to "individuals in recognition of distinguished contributions to applied mechanics without restriction as to nationality or profession." Presentation will be made at the annual ASME meeting Dec. 4 in New York.

John Chipman, head of the Metallurgical Dept. of MIT, slated for double recognition by The American Society for Metals: as the winner of its Gold Medal and as the recipient of its senior award. Chipman, says ASM, "helped lift metallurgy to a highly respected plane of science and engineering" with contributions in the fields of slag control, oxidation and deoxidation, and high-temperature chemistry.

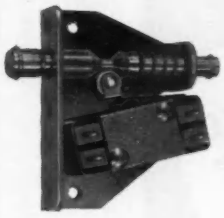
Tokushicki Mishima, professor emeritus, University of Tokyo, scheduled for the ASM's Albert Sauveur Achievement Award for his work in perfecting strong permanent magnets. The award credits "Japan's most eminent living metallurgist" with "insight, patience, and enterprise", says his work has stimulated a "marked basic advance" in metallurgical knowledge, and nutshells his latest contribution: discovery of the answer to why magnetized high-nickel steel becomes nonmagnetic after high heat and slow cooling.

Roy C. McKenna, chairman of Vanadium Alloys Steel Co., Latrobe,

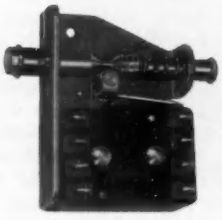
TYPICAL ELECTRO-SNAP INTERLOCKS

Push to operate;
returns automatically.

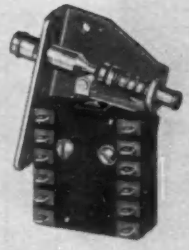
Pull to operate;
remains in operating position until reset for automatic return by next full-stroke push operation.



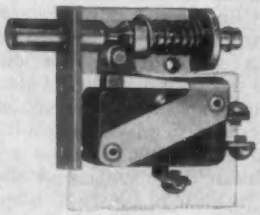
MODEL C2-4 S.P.D.T. 2 ckts. **Elec. rating:** 125/250 V.A.C., 30 V.D.C. —10 amps. 125 V.D.C., ½ amp. 250 V.D.C., ¼ amp. **Oper. force:** 2 lbs. ± 12 oz. **Weight:** 2 oz. **Dimensions:** 1-13/16" x 1-31/32" x 9/16"



MODEL C2-9 D.P.D.T. **Elec. rating:** 15 amp. 125/250 V.A.C. 60 cycle. **Oper. force:** 4¾ lbs. ± 12 oz. **Amb. temp:** —100° to + 275° F. **Elec. & Mech. Life:** 150,000 ops. **Weight:** 2 oz. approx. **Dimensions:** 1-29/32" x 1-31/32" x 9/16"

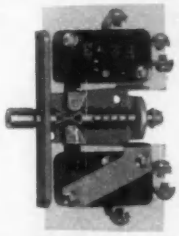


MODEL C2-14 T.P.D.T., 6 ckt. **Pre-travel:** 5/32" min. **Overtravel:** ¼" approx. **Mov. Diff.** .028" ± .007" **Elec. rating:** 15 amp. 125/250 V.-A.C.—15 amp. 30 V.D.C., res.—10 amp. 30 V.D.C., ind. **Life**—500,000 ops. min. **Dimensions:** 2-5/16" x 1-31/32" x 9/16"



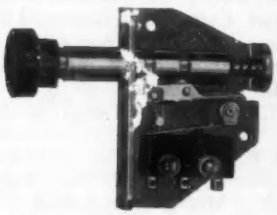
MODEL C2-5 Solid shaft. S.P.D.T. **Elec. rating:** 10 amps. @ 125/250 V.A.C., 60 cycles. **Oper. force:** 2 lbs. ± 12 oz. **Amb. temp.:** —100° to + 275° F. **Elec. & Mech. life:** 150,000 ops. **Weight:** 2 oz. **Dimensions:** 1-13/16" x 1⅞" x ½"

MODEL C2-10 same as C2-5, except has threaded shaft.

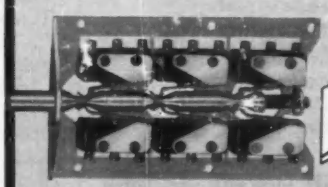


MODEL C2-7 Solid shaft. D.P.D.T. **Pre-travel:** 3/16" max. **Elec. rating:** 10 amp. 125/250 V.A.C. 60 cycle. **Amb. temp.:** —100° to + 275° F. **Elec. & Mech. life:** 150,000 ops. **Dimensions:** 2-3/32" x 1⅞" x 33/64"

MODEL C2-6 same as C2-7, except has threaded shaft.



MODEL C2-15—Subminiature interlock. S.P.D.T.; **Elec. & Mech. Life and Rating:** 150,000 ops. @ 2.5 Amps., 125/250 V.A.C.; 100,000 ops. @ 5 amps, 125/250 V.A.C. **Dimensions:** 1-13/16" x 1¼" x 9/16". Various colored buttons available.
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WHAT'S NEW

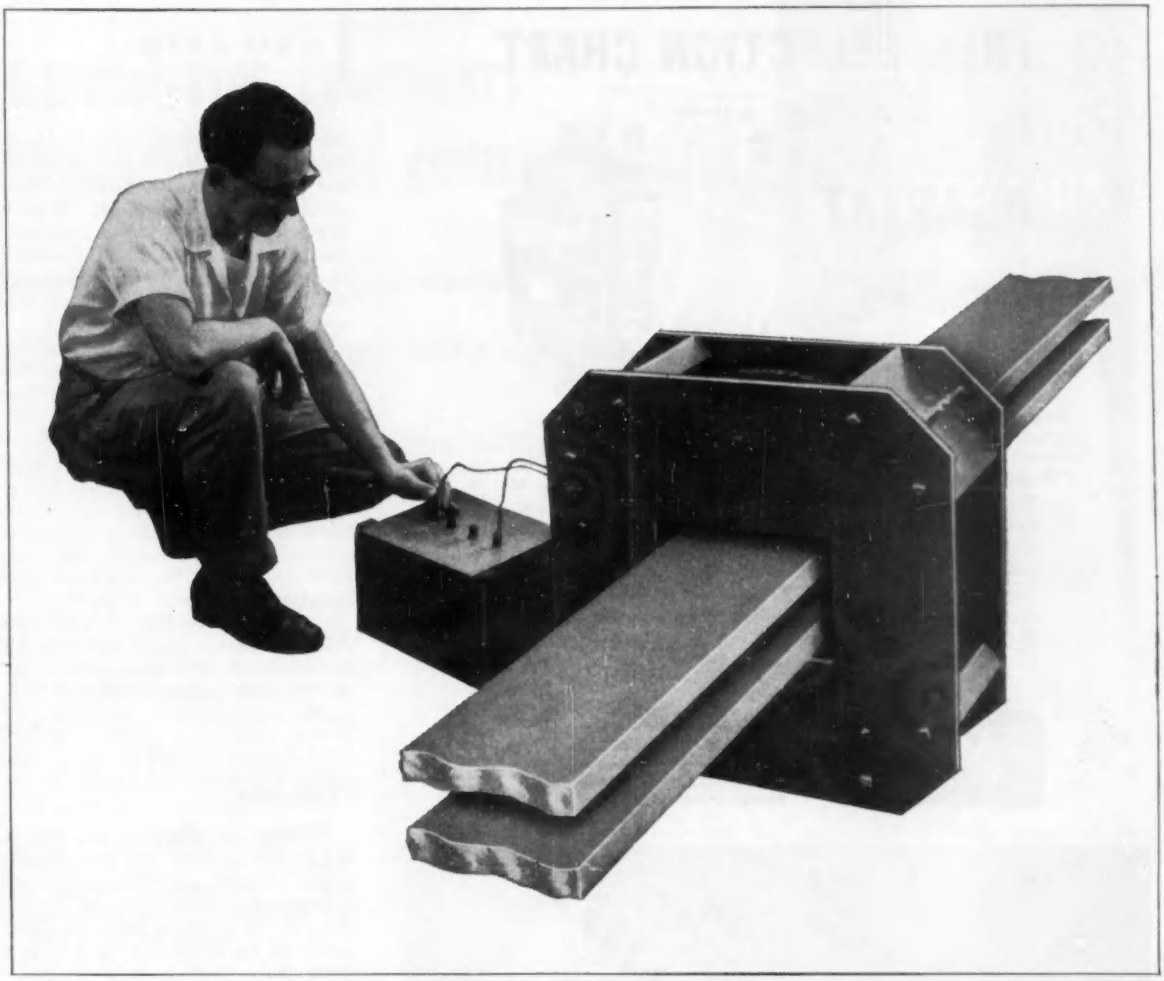
Pa., named to receive the ASM's Gold Medal for Advancement of Research for his "unqualified belief in advancement through research, his continuously expressed belief that a metallurgical research department should be independent of operating or other administrative company groups, and his belief in the delegation of responsibility". McKenna's ideas on research were considered just a little short of radical when he first took over Vanadium in 1915. Today they're considered standard procedure. Fortunately, the ASM's practice of awarding a medal for his kind of contribution is also standard procedure. Other societies in and around control engineering would do well to copy it. All that's needed is a slight change in the wording of the citation.

Chipman, Mishima, and McKenna all pick up their awards at the National Metals Exposition & Congress in Chicago this month. Last month, at about the same time, another society, the AIEE, presented its Medal in Electrical Engineering Education and named 16 new fellows. The occasion was the Fall General Meeting in Chicago; those honored:

William L. Everitt, dean of the College of Engineering, University of Illinois, who received the AIEE medal "in recognition of his distinguished service as a teacher of electrical engineering and as evidence of the high esteem in which his contributions to engineering education are held by his fellow members of the American Institute of Electrical Engineers", and these men in industry:

Theodore Brownlee and **John L. Cantwell,** GE; **Joseph H. Cox** and **William R. Harris,** Westinghouse; **Emanuel L. Brancato,** National Research Laboratory; **James C. Clark,** University of Arizona; **Waldo E. Enns,** Portland (Ore.) General Electric Co.; **Ronald M. Fairfield,** British Insulated Callender's Cables, Ltd., London; **John G. Ferguson,** Bell Telephone Laboratories, Inc.; **Arthur P. Hill,** Pacific Telephone & Telegraph Co.; **Arthur V. Loughren,** Airborne Instruments Laboratories; **Wayne J. Morrill,** Electric Motors & Specialties Co., Garrett, Ind.; **Ralph E. Neidig,** Metropolitan Edison Co., Reading, Pa.; **Edward J. Schaefer,** Franklin Electric Co., Bluffton, Ind.; **Alwin G. Steinmayer,** Line Material Industries Div. of McGraw-Edison Co., Milwaukee, Wis.; and **Stanley C. Townsend,** Pennsylvania Power & Light Co., Allentown, Pa.

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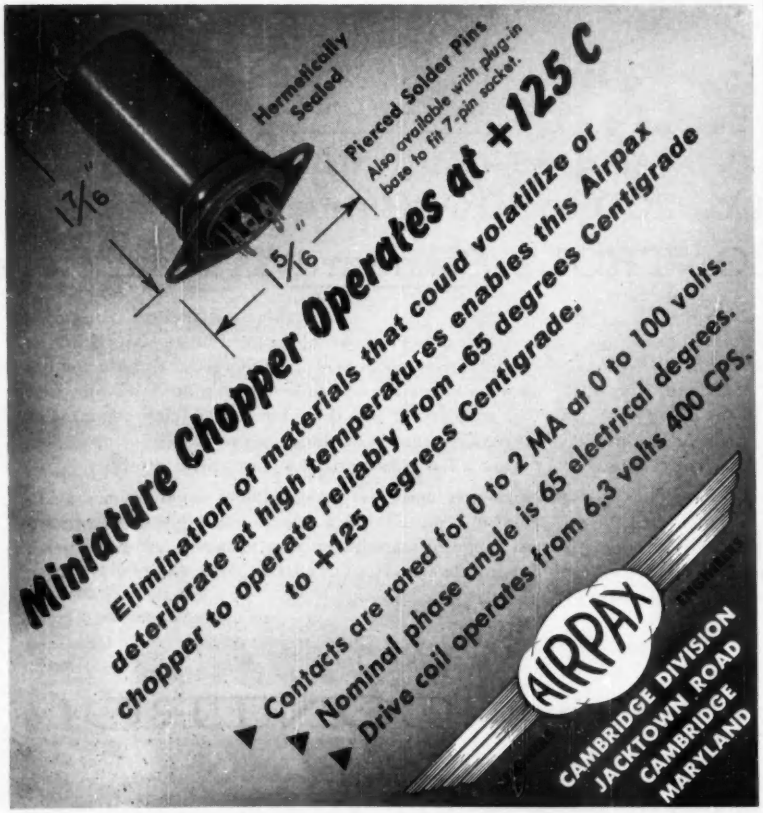
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WHAT'S NEW

the Franklin Institute held its annual Medal Day ceremonies in Philadelphia and presented its Elliott Cresson Medal to **Sir Robert A. Watson-Watts,** radiophysicist of Toronto, Can., and its John Price Wetherill Medal to **Warren W. Carpenter,** who retired from the Bell System in 1951 and now lives in Winter Park, Fla.

Watson-Watts, whose previous honors include the U. S.'s top civilian award, the Medal of Merit, was cited "for his conception of pulsed radar for the vital air defense of Great Britain, for his solutions of important technical problems, and for his inspiring leadership which resulted in the timely development of these radar systems". In Wetherill's case, the institute noted "his important contributions in the field of switching, including the invention of the automatic message accounting system and many related inventions fundamental to the technology of modern telephone switching".

Obituaries

Weldon H. Brandt, 47, veteran Westinghouse man who was recently named director of advanced systems engineering in the Sunnyvale (Calif.) Div., at his home in Saratoga, Calif. Cause of his death was apparently a heart attack.

Henry D. James, 83, for 30 years an engineering executive with Westinghouse, holder of more than 150 patents for inventions centering around electric motors, and co-author of the book, *Controllers for Electric Motors,* at his home in Pittsburgh. He had been a consulting engineer since 1934.

Arthur W. Richards, 72, chairman of the board and general manager of Designers for Industry, Inc., and an authority on engineering management and on the application of creative engineering to industry, at St. Luke's Hospital, Cleveland.

G. Steward Crane, 69, chairman of the board of Cutler-Hammer, Inc., in Milwaukee. Death was due to a heart attack.

Dr. Irvin Langmuir, Nobel-prize winning scientist retired from GE's Research Laboratories, credited with uncovering a new branch of chemistry with his experimentation with oil films on water, and with additional important research in electron emission, gaseous discharges and rain making; of a coronary thrombosis. He was 76.

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Relays. Kellogg relays are of simple design and sturdy construction, built to the most exacting specifications. They can be furnished in a wide variety of spring combinations and coil resistances. Types available include—alternating current relays, micrometer adjustment relays, trip and restoring relays, harmonic relays, polarized relays. Magnetic impulse counters.

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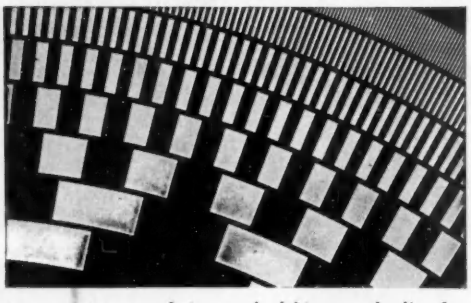


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Gurley, manufacturer of the *standard* binary code disc for the electronics industries, is now able to supply four versions for use in either photo-electric, magnetic or contact types of pickups.

Containing concentric zones of information in the gray (reflected) code, the Gurley discs contain alternate clear and opaque sectors. Thin annular rings separating adjacent zones are opaque. Varying patterns record up to 8192 bits of information (65,536 on special designs!).

Four coatings are available: "Type T"—photoengraver's glue with colloidal (black) silver, essentially grainless; "Type R" with etched metal coating, for reflectivity and transmission contrast; "Type M" with chemically deposited ferrous alloy possessing both *magnetic* and optical transmission contrast; and "Type C"—metal bonded on glass for electrical *contact* use as well as in contrast of optical transmission. WRITE FOR BULLETIN 7000.

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ABSTRACTS

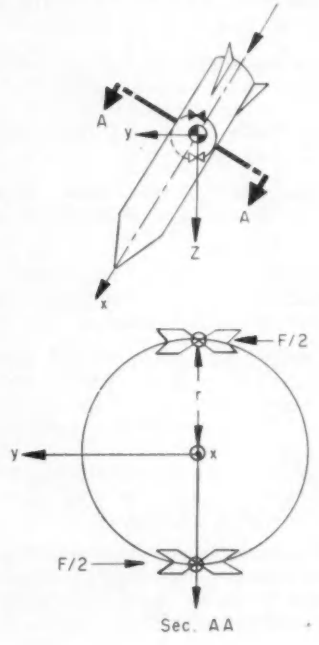
On Missile Control

From "Phase-Plane Trajectories as a Tool in Analyzing Nonlinear Attitude Stabilization for Space Missile Application" by Jack L. Halvorsen, Lockheed Missile Systems Div. Paper presented at the Annual Wescon Convention, San Francisco, Calif., Aug. 21-24, 1957.

In those missile control applications that can tolerate some steady-state oscillation in displacement angle, the on-off servo is extremely helpful in conserving control energy in the presence of system noise. An attitude-stabilization system using a two-way relay servo, reaction jets, HIG gyros, and lead networks for an equivalent rate and position feedback, provides this type of steady-state response.

Phase-plane techniques are presented here to determine the relationship between frequency, required impulse, maximum rates, and maximum displacement as a function of lead network parameters, inherent hysteresis, jet force, and time lag. Analog computer techniques verify the examples presented.

If the transfer function for the lead network is appropriately expanded, the problem lends itself to phase-plane solution. Where the initial conditions are known, the phase plane gives the transient and steady-state response within the accuracy of a graph. The effects of inherent hysteresis, time lags,



New timing motor rated 60 in-oz torque...

New permanent magnet motor series by Cramer includes "double-strength" and military versions

High torque output, truly synchronous operation, instant starting and stopping, are inherent features of permanent magnet timing motor design. These advantages have been optimized in the new Cramer Type 117, resulting in a motor line with maximum application flexibility.

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Series 117 comes in five basic forms (1) Form P, the standard, highest quality 30 in-oz (at 1 rpm) instrument motor, (2) a militarized version of Form P, (3) Form H, a "double strength" version, (4) Form M, for economy in high volume use, and (5) Form N, a compact, cylindrical gear-train model.

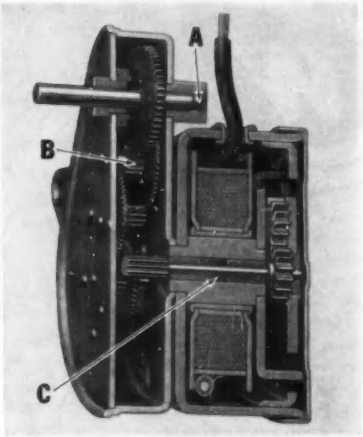
All have these features: instant starting, absolutely synchronous operation, and permanent magnet braking. Coil voltages up to 250V ac, 50 and 60 cycles. Input less than 2.5 watts at rated voltage. Temperature rise only 35°C. Ambient temperature range −20°F to +130°F. Gears all hobbed, with drawn pinion rod. Underwriters' Laboratories approved.



NEW CRAMER TYPE 117 MOTOR. The Type 117 motor, in its several forms, replaces Cramer Types 111, 112, 113, 114 with greatly improved performance.

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The standard version of the Type 117 motor, Form P, is rated 30 in-oz torque at 1 rpm. It's ideal for instruments and industrial control devices requiring field-proved dependability, timing accuracy and longest service life. Oilite rotor bearings, bronze upper and lower output bearings, and a ball thrust bearing backing up the output shaft give exceptional life and performance. A soldered gear cup cover keeps dirt out and lubricant in. Over 100 available speeds from 1 rev. per second to ½ rev. per day.



IMPROVED BEARINGS help double life expectancy of Type 117 motors. Forms P, H feature ball thrust (A) in lower output bearing. All forms boast hobbed gears throughout (B), and Oilite rotor bearings with permanent supply reservoir (C).

Double-strength version, too

Type 117 is offered also in a "double-strength" model, (Form H) rated 60 in-oz at 1 rpm. Applications are in heavy chart recording devices, high speed counters and the like, requiring high torque at fast speeds—as, for example, in the Cramer Type 640E running time meter which reads in 1/10 seconds. Readily available in speeds 60 rpm to 2 rpm. Like the Form P, external finishes are tin and cadmium plate, protected by clear iridite.

A form for economy

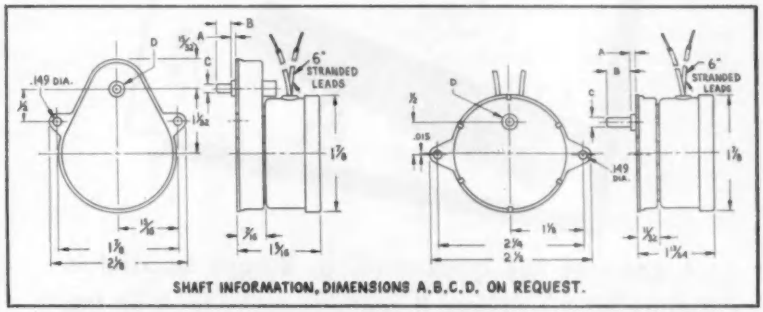
Economy for volume applications is dominant in the Type 117, Form M motor. It has the same torque and wide variety of speeds as the standard industrial version, Form P, above. A few differences: Ball thrust bearing is not used. Gear cover is crimped (instead of soldered) and external finishes are natural brass and black oxide. Advertising displays, appliance timers, vending machines are typical applications.

This one saves space and money

A space-saving cylindrical gear train —same diameter as the basic motor— is the big feature of Form N, Type 117. Basic motor is the same as the economical Form M above. Ideal for limited space applications, Form N is offered in speeds from 60 rpm to 1/12 rpm.

MilSpec model

The militarized version, identified as "Form P, Military," is practically identical with the standard version except for the coil which (here) is vacuum impregnated and supplied with high-temperature rated insulation on the leads. Ambient operating temperature range −55°C to +85°C.



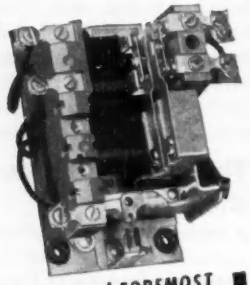
DIMENSIONS: Type 117 motor, Forms P, M and H (left). Form N (right).

Write for complete data on the new Cramer Type 117 motors today. Or better yet, ask your nearest Cramer representative to tell you about them. Cramer Controls Corporation, Box 46, Centerbrook, Connecticut. 7.30

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ABSTRACTS

and extraneous torques are easily determined.

The figure on page 202 illustrates the configurations of a typical missile roll control, and is presented along with a dicussion of missile roll dynamics. The equation of motion derived in this section is later used to develop the phase-plane trajectories.

Simplifying Control Math

From "Ueber einige Verfahren zur Behandlung von Regelungs-Differentialgleichungen vierter Ordnung und ausgewahlte Anwendungsbeilspiele", by I. M. Lorenz, published in "VDI-Forschungs-Hett", No. 460, 1957, Dusseldorf, Germany.

The mathematical treatment of control systems design usually involves the solution of linear homogeneous differential equations with constant coefficients. All control systems having four time constants lead to fourth-order differential equations.

In every case the differential equation is solved by setting up the characteristic equation which results when using a suitable assumption, e.g., by introducing the condition

$$x = c_1 e^{r_1 t} + c_2 e^{r_2 t} + c_3 e^{r_3 t} + c_4 e^{r_4 t} + \cdots \quad (1)$$

where x is the error (difference between the actual value and the desired value of the controlled variable), t is the time, c_1 to c_4 are constant coefficients, and r_1 to r_4 are the roots of the characteristic equation

$$a_4 r^4 + a_3 r^3 + a_2 r^2 + a_1 r + a_0 = 0 \quad (2)$$

with the argument r and the constant coefficients a_0 to a_4 which result from the differential equation.

The new method of solving these equations consists in introducing the transformation

$$r = \sqrt[4]{a_0/a_4} \times R \quad (3)$$

giving the characteristic equation.

$$R^4 + CR^3 + BR^2 + AR + 1 = 0 \quad (4)$$

for the new argument R with only three constant coefficients, A, B, and C. Using the value of B as parameter ($B = 3, 4, 5$, etc.) the values of A and C can be obtained from graphs which contain curves of constant damping decrement, stability limits, oscillation frequencies, and constant real solutions to Equation 3. These graphs are a valuable aid to the designer of control systems which can be represented by a fourth-order differential equation. Of value, too, is the possibility of determining what varying the time constants will do to stability and the transient response.

Russians Push Magnetics

MAGNETIC AMPLIFIERS *by M. A. Rozenblat, 823 pp. Moscow, 1956, in Russian. Translated and reviewed by Michel Mamon, consulting engineer, Control Instrument Div. of Burroughs Corp.*

This book combines various papers written by a Russian authority in the field of magnetics and dating from 1947, with a short book published by him in 1949. From the introduction we learn that the Russians have been interested in magnetic amplifiers for a long time (the Shenfer magnetic audio amplifier was developed in 1920) and that lately there has been a technological push to study and expand the use of magnetic amplifiers in the field of automation.

It appears that high permeability and square-loop core materials are available in Russia, but no mention is made of silicon rectifiers. Only the characteristics of selenium, copper-oxide, and germanium rectifiers are shown. A search through various Soviet technical publications has led this reviewer to believe that silicon diodes are not yet available in that country, and that the Russians may thus be handicapped in high temperature magnetic amplifier applications.

Simple mathematics are used throughout the book. Although the American book on magnetic amplifiers by H. F. Storm was translated into Russian, his elegant methods of analysis are not reflected here.

Much of the work covered in Rozenblat's book finds a parallel in the American literature. Still, there is enough new material to warrant a detailed account in this department. Four circuits that are typically Russian are reproduced to further highlight the present state of Russian knowledge of magamps.

Transients in magnetic amplifiers

It is shown that for all practical purposes the effects of transients in gate windings can be neglected. See Figure 1. The time constant of the control circuit is the determining factor and it is due mainly to the time lag between the control current and the control voltage. The expression for the time constant of the control circuit, valid for all types of magnetic amplifiers, is given as:

$$\tau = \frac{\mu H_c^2 V}{0.4\,\pi\,10^8\,P_c}$$

where P_c is the total power available from the signal source and V is the volume of the core.

For magnetic amplifiers with feedback a small time constant is obtained through small values of H_c. For multistage magamps the time-constant reduction of the first stage is achieved by using small H_c and V; for succeeding stages, the signal power is increased.

The introduction of a derivative feedback reduces the duration of transients five to 15 times. It is shown that for a single ended external feed-

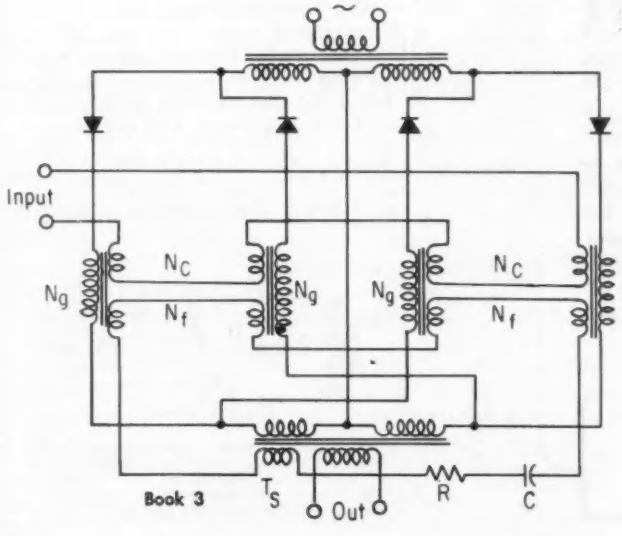


FIG. 1. Self-saturating push-pull magnetic audio amplifier in which R, C, T_s, and N_f form a derivative feedback to improve the amplifier's transient characteristic. The absence of ballast resistors increases efficiency, while the push-pull connection offers less nonlinear distortion and extended linear input-output characteristic.

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back magnetic amplifier a derivative feedback through R, C, and N_s can produce a fast decaying transient if $N_s > N_t$, and undecaying transients if

$$N_s \geq N_g\left(1 + \frac{L_c}{R_c R_L C}\right)$$

Great care must be taken in the design of derivative feedbacks, especially if R_L or R_c varies to a large degree since then the magnetic amplifier can pass from aperiodic to oscillatory condition and vice versa.

Derivative feedback can be achieved in magnetic amplifiers with ac output without using rate transformers or rectifiers. For example, in a multistage amplifier with ac output, a stabilizing winding N_s can be wound on the last stage and connected to a second control coil N_{c2} of the first stage through a resistor. A capacitor placed across N_{c2} removes the coupling for even harmonics. The derivative effect results from the fact that as the average value of load current is proportional to ϕ_s of the last stage, the variation of ϕ_s will induce a voltage in N_s and the action is similar to a rate transformer.

Magnetic voltage amplifiers

One chapter gives an excellent treatment of magnetic modulators of fundamental and second harmonic types. It describes differential and bridge type magnetic modulators of the first type having a null stability equivalent to 10^{-14} watts. The stability for the second harmonic type is 10^{-19} watts. Figure 2 shows the circuit for a low-level amplifier with high zero stability (threshold of response) of 10^{-14} watts.

Also covered is magnetization of ferromagnetic cores with two superimposed parallel fields of different frequencies (Figure 3). It is shown analytically that when the ratio of two excitation frequencies is of the form:

$$p/q = \frac{2k}{2j+1} \text{ and } p/q = \frac{2k+1}{2j}$$

a magnetic flux rectification takes

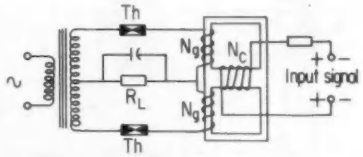


FIG. 2. This low-level magnetic amplifier has high stability about null, leading to a threshold of response of 10^{-14} watts. The symbol Th represents a nonlinear voltage-sensitive resistance such as thyrite.



Here E. V. Stearns (left), Inertial Guidance Department Manager, and G. D. Schott, Flight Controls Department Manager, discuss preliminary design of guidance and control systems.

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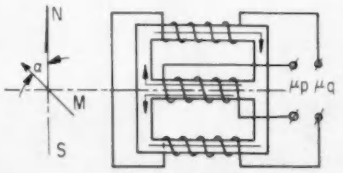


FIG. 3. Circuit for demonstrating magnetic flux rectification.

place, the constant component of which has a maximum value for $p/q = 2, 4, 6 \ldots$ or $p/q = \frac{1}{2}, \frac{1}{4}, \frac{3}{2}, \frac{3}{4} \ldots$ Physically, the rectification occurs because the permeability under these conditions is not the same for positive and negative halfcycles.

The existence of the magnetic flux rectification can be shown experimentally, using the circuit in Figure 3. Here, the magnetic needle will deviate each time the frequency ratio satisfies the conditions outlined above. The author states that this rectification is the cause of instability in low-level push-pull and multistage magnetic amplifiers.

Simultaneous excitation

Second harmonics are induced in many magnetic amplifier circuits with dc premagnetization, which produces additional premagnetization according to the principle of magnetic flux rectification. This action has the effect of increasing or reducing the magnetic permeability depending on circuit configuration. The incremental permeability is higher under sinusoidal field excitation and dc polarization than under sinusoidal flux excitation. This is due to the presence of even harmonics in the magnetic field under sinusoidal induction and dc polarization. It follows that in order to obtain a given incremental permeability the necessary H_o must be smaller in the absence of induced second harmonics. That is, less dc signal is required.

When a ferromagnetic core is subjected to simultaneous ac and dc magnetization the change in the magnetic state does not take place along the normal magnetization curve but along minor hysteresis loops, and the mag-amp output characteristic tends to become double-valued. To avoid this, the ac flux must traverse all paths of the core (by using split cores) where the dc polarization is present.

Double value may also arise from the skin effect, which can be removed if the thickness d of laminations or tapes is selected such that:



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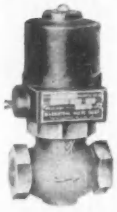
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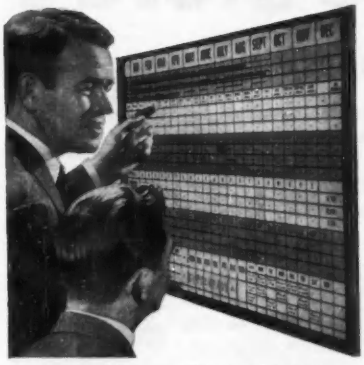
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$$d \leqq L \frac{1}{\pi \sqrt{f a \mu}}$$

where: $a = 10^{-9}/\rho$, ρ = resistivity, μ = permeability, f = frequency. This inequality applies particularly to magamps without dc bias, such as magnetic modulators of second harmonics, for which $H_{eff} < H_{max}$.

With dc present the thickness is given by: $d \leqq 1/\pi\sqrt{2fa\mu}$ cm. For MO Permalloy cores the recommended thickness is: $d < 2/\sqrt{f}$ mm. When *D-U* laminations are used the equivalent permeability is:

$$\mu_{eq} = 1/\left(\frac{1}{\mu} + \frac{ad}{4bl_m}\right)$$

where a = insulation thickness, d = lamination thickness, b = width of the narrow leg, and l_m = mean magnetic path.

Amplifiers with feedback

The feedback factor K of a magnetic amplifier with a real rectifier is defined as:

$$K = \frac{H_{feedback}}{H_{average}}$$

From this relationship, the author has worked out the feedback factors for the five most common types of magnetic amplifiers:

Single-core half-wave—

$$K = \frac{R_r - R}{R_r + 2R_L + 2R_g + R}$$

Doubler circuit with ac load—

$$K = \frac{R_r - R}{R_r + 2R_g + R}$$

Center tap circuit—

$$K = \frac{R_r - 2R_L - R}{R_r + 2R_L + 2R_g + R}$$

Bridge-type circuit—

$$K = \frac{R_r - R_L - R}{R_r + R_L + 2R_g + R}$$

External feedback circuit—

$$K = \frac{R_r - R}{R_r + 2R_L + 2R_f + R} \cdot \frac{N_f}{N_g}$$

where: R_r and R are the reverse and forward rectifier resistances, and R_L, R_g, and R_f are the load, gate, and feedback coil resistances.

Push-pull amplifiers

With parallel connected ballast resistors R_b, (Figure 4) each single amplifier should be designed for an equivalent load:

$$R_{eq} = \frac{2R_b R_L + R_b^2}{R_b + R_L} = 2R_L$$

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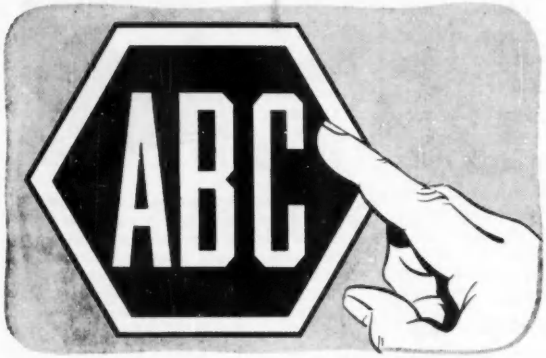
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Institute of Radio Engineers, 3rd Annual Technical Conference, Professional Group on Electron Devices, Shoreham Hotel, Washington, D. C. Oct. 31-Nov. 1

Institute of Radio Engineers, 4th Annual Meeting, Professional Group on Nuclear Science (emphasis on reactor instrumentation and controls), Henry Hudson Hotel, New York Oct. 31-Nov. 1

NOVEMBER

International Metal Exhibition and Congress (39th annual), International Amphitheatre and Palmer House, Chicago Nov. 2-8

International Congress & Exhibition of Instrumentation & Automation (INTERKAMA), Dusseldorf, Germany Nov. 2-10

American Institute of Electrical Engineers, 9th Annual Machine Tool Conference, Hotel Schroeder, Milwaukee, Wis. Nov. 4-6

American Institute of Electrical Engineers and Instrument Society of America, 10th Annual Conference on Electronic Techniques in Medicine and Biology, Harvard University, Cambridge, Mass. Nov. 6-8

Institute of Radio Engineers, 3rd Instrumentation Conference and Exhibit; theme: Instrumentation for Data Handling, Baltimore Hotel, Atlanta, Ga. Nov. 11-13

Institute of Radio Engineers and American Institute of Electrical Engineers, Conference on Magnetism and Magnetic Materials, Sheraton-Park Hotel, Washington, D. C. Nov. 18-21

DECEMBER

American Society of Mechanical Engineers, Annual Meeting and Exposition, Hotel Statler, New York Dec. 1-6

Institute of Radio Engineers, American Institute of Electrical Engineers, Association for Computing Machinery, Eastern Joint Computer Conference and Exhibition, Sheraton Park Hotel, Washington, D. C. Dec. 9-13

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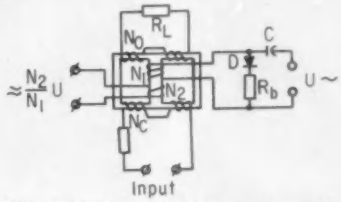


FIG. 4. In this push-pull magnetic amplifier, diode D and the ballast resistance R_b provide dc bias, while C prevents the rectified current from flowing back to the ac source. Because the ac flux in the common leg is independent of the dc signal, winding N_2 can provide an auxiliary voltage different from U to energize some other element of the system.

(For maximum power $R_b = \sqrt{2}\, R_L$. Equivalent load current $I_{eq} \sim 1.7 I_L$.)

For series mixing dc output each single-ended amplifier should be designed for an equivalent load.

$$R_{eq} = \frac{R_b^2 + R_L R_b}{2R_b + R_L} = \frac{R_L}{2}$$

(For maximum power $R_L = \sqrt{2}\, R_b$. Equivalent load current $I_{eq} \sim 3.4 I_L$.)

After considering the above, it is recommended that series mixing be used for circuits with high values of R_L and that parallel mixing be used for small values of R_L.

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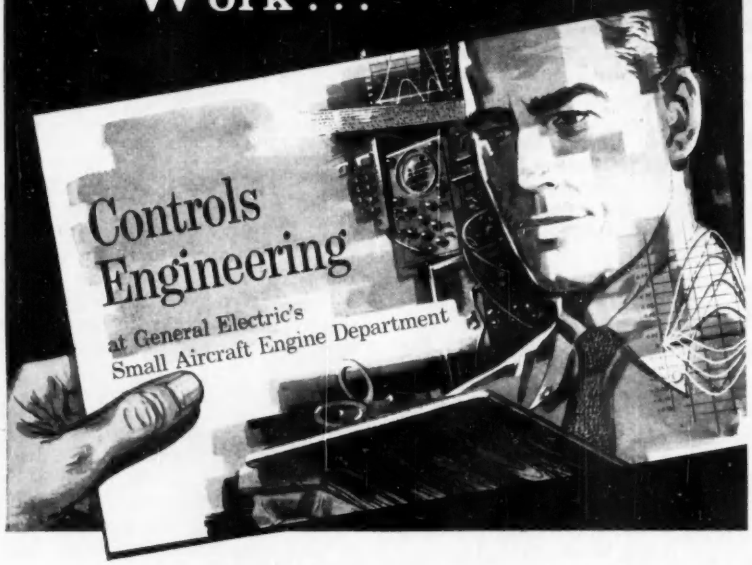
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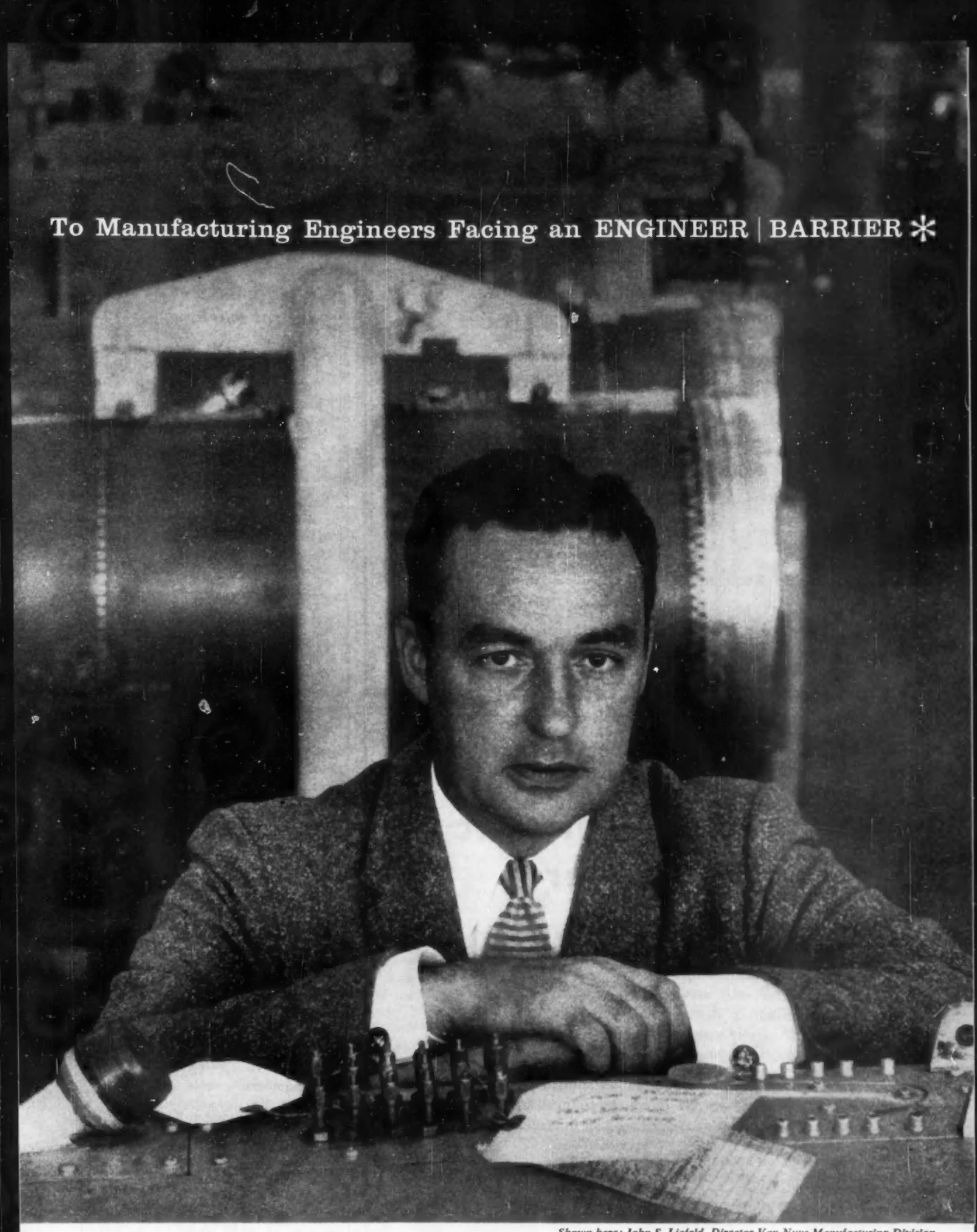
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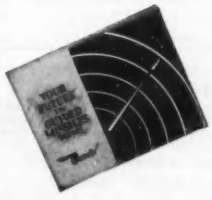
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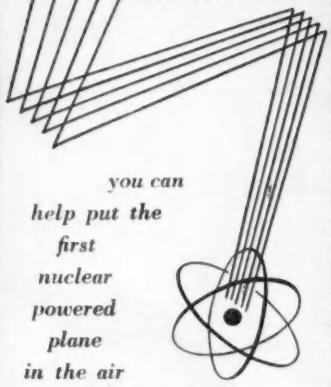
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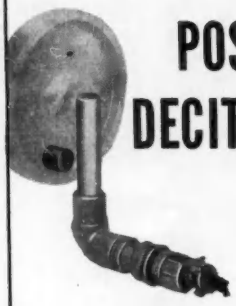
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Many years ago in a far-off land, there journeyed two worthy lads in search of their fortune. The elder of the two was called *Maximus*—he was quick. The younger was called *Optimus*—he was thorough.

By and by they came upon a town plagued by MICE! Forthwith they went to the Lord Mayor to offer their services. The Lord Mayor said to Maximus, "If thou be quick, bend thy talents to the task of ridding our town of mice." Max got right to work . . . *building a better mouse trap!*

His new traps were quick and sure. In three days they netted three thousand mice. But the mice soon got wise, and the effectiveness of the traps dropped sharply. So, Max devised even better traps. But they too were only effective for a while. And the mice continued to multiply faster than Max's new traps could control them. All agreed that "a better mouse trap" was not the answer.

Then Optimus up and offered this advice—

"What better traps have failed to relieve,
Might by reason be best achieved."

"Blast the reason, get it done," bellowed the impatient Lord Mayor.

"No pied piper am I, said Opt with a twinkle, "so I must play a different tune." And off he went to hatch a scheme that would make monkeys out of mice and mirthful men out of mournful minions.

After Opt's plans were drawn up, he summoned fourscore painters, carpenters, and stationers. When all the work was completed, he called a temporary truce and invited the King of the mice over for a little cheese-and-cracker chitchat.

"We're planning a big festival and would like you and your subjects to join us. There will be much food and rejoicing for both mice and men. In addition, we would like to have you and your subjects give a *Roll-A-Mouse Derby*."

"Give a what?" piped the King of the mice. "It's a special kind of race, held by the mice in my homeland during every festival," said Opt. "The mice line up on a high hill with their tails curled up and over in a large loop. At the starter's cue, each mouse puts the tip of his tail into his mouth . . . closes the loop . . . and at the word "go," pushes off from the starting line with his hind legs . . . rolling end over end down the hill. The first to reach the bottom wins the race and gets the grand prize."

The King agreed to give the derby. And at high noon on the following day he led his subjects to the top of the appointed hill. Squeaking and squinting in the noonday sun, they all anxiously awaited the start of the race.

Just before starting time, the King mouse said to Opt, "I do not see well in daylight, but there seems to be straw at the bottom of the hill."

"Better to hide the sea," mumbled Opt.

"What was that?"

"Better to land more softly," Opt replied in a loud voice. Convinced that all was well, the King got in line with his brethren.

"GET SET . . . LOOP TAILS UP . . . CLOSE THE LOOP AND GO!" Down they rolled, end over end, one and all, faster and faster toward the bottom. The dust flew and the people cheered as the mice gathered speed. As the first mouse reached the bottom of the hill there was heard a loud rip . . . then another and another . . . all down the line . . . till one and all had reached the bottom and disappeared. At that moment all realized what Opt had done—the bottom was nothing but paper tacked up on frames of wood, painted to look like straw. *And it worked!*

With the Roll-A-Mouse Derby successfully concluded and all the mice gone, the festival really began . . . with Optimus, *and* Maximus, as the honored guests.

MORAL FOR PROCESS DESIGNERS
Maximizing works! . . . but only to a degree, because it doesn't get at the heart of the problem—the PROCESS. Optimizing, on the other hand, gets to the heart by examining the dynamics of the process . . . by controlling these dynamics with the delicate touch of fine instruments.

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